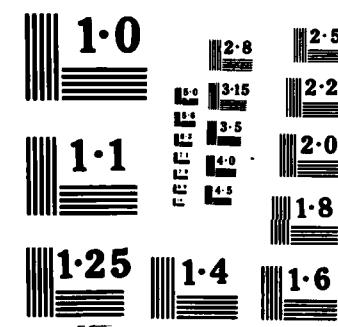


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# **Unit Cost Analysis**

## **Annual Recurring Operating and Support Cost Methodology**

John F. Schank, Susan J. Bodilly,  
Richard Y. Pei

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John F. Schank, Susan J. Bodilly,  
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March 1986

Prepared for the  
Office of the Assistant Secretary of Defense/  
Reserve Affairs



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## PREFACE

This report describes a methodology for estimating the annual operating and support costs of units in the active and reserve force components of the military services. The methodology is based on methods used in the military services' own manuals and procedures with some modifications and interpretations. This report presents the results of case study analyses of comparably equipped active and reserve force units in the Air Force, Army, and Navy and draws inferences about the factors that affect both the annual costs of units and the cost differential between the active and reserve components. The Rand Defense Manpower Research Center conducted the research described herein for the Office of the Assistant Secretary of Defense (Reserve Affairs) under Task Order 84-III-2, Economic Analysis: Reserve Components Within the Total Force, Contract MDA903-85-C-0030.

Those concerned with the annual costs of active and reserve force units and with force mix cost issues should find this study of interest. The analytical approach and the case study results are summarized in *Unit Cost Analysis: Executive Briefing*, R-3210/1-RA, May 1985.

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## SUMMARY

Both the administration and the Congress recently expressed increased interest in the role of the reserve and guard components in the Total Force concept. This interest was triggered by the rising defense budgets and the widely perceived notion that reserve force units have considerably lower annual recurring costs than have comparably equipped active units.

The cost of a change in the active/reserve balance depends on how that change is implemented. For example, in the transfer of equipment from the active to the reserve forces, military capabilities may be held constant or changed, equipment may be transferred without a complete transfer of missions, or new facilities may be required. Also, the activities of seemingly unrelated units may be affected. Each of these factors can imply different unit manning and activity levels, changed flows through formal and on-the-job training, and significant start-up costs. Unfortunately, past cost studies of active and reserve force units have suffered from the lack of a consistent estimating methodology and suitable data factors that yield comparable and sufficient cost estimates. Without a suitable cost estimating capability, analysts cannot provide the cost detail needed for force mix decisions.

This report describes research on a major ingredient of any cost analysis of changes in the active/reserve balance: estimation of annual operating and support (O&S) costs of similarly equipped active and reserve units. The report presents a framework for estimating annual unit costs—based on current service cost estimation methods—and describes the results of applying the costing methodology to selected case study units in the Air Force, Army, and Navy. The report also offers general observations on the factors that drive the annual costs of active and reserve force units and contribute to the resulting cost differentials.

## UNIT COST METHODOLOGY

The cost methodology provides estimates of the annual recurring costs of unit personnel, peacetime equipment operations, and peacetime base support. These estimates are based on the average variable costs of existing units. They do not include equipment development and procurement costs or the fixed costs of force administration, base operating support, and training school operations. Because the

resulting cost estimates are based on the current force structure, they are appropriate for small changes in the current force but may underestimate the costs of large changes in the mix of active and reserve force units or changes in overall mission responsibilities.

The annual operating and support cost estimating model combines personnel and equipment factors in a series of simple linear equations. Personnel-related costs include pay and allowances, the acquisition and training of personnel to replace losses during the course of a year, and miscellaneous expenses, such as travel, medical costs, and bonuses. The cost of military retirement, based on the aggregate entry age normal model used by the Department of Defense Actuary, is also included. Most necessary per capita cost factors are derived from information contained in the component's Personnel Budget Justifications and Operations and Maintenance Budget Justifications.

Equipment-related costs include fuel, spare parts, training ordnance, higher-level (above unit) maintenance, and other expenses, such as modifications and replacement support equipment. These costs are based on the numbers and types of unit equipment, the peacetime programmed operating levels, and fixed and variable cost factors.

Base support costs include the cost of the variable base operating support, real property maintenance, and medical support personnel, plus a per capita cost factor for rentals, utilities, communications, and other support expenses.

The model deals solely with annual unit O&S costs at proposed peacetime operating tempos. Although programmed operating tempos are designed to maintain unit proficiency, there is no guarantee that comparably equipped units have comparable capability.<sup>1</sup> Thus, no conclusions about the desirability of transferring equipment or missions from one component to another can be drawn from examining O&S costs alone. Obviously, cost is only one input into force mix decisions. The overall analysis of the appropriate mix of active and reserve force units must also consider such factors as capability measures, rotation base requirements, and legislative constraints.

## CASE STUDY RESULTS

The analyses of selected units in the Air Force, Army, and Navy show different results. The annual cost of the Army National Guard units studied (infantry, armor, artillery, and engineer battalions) was

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<sup>1</sup>Many factors will affect capability and must be considered in making comparisons. Factors include the mission of the units; the experience base of the units; the available diversity of training opportunities including unit level training, division or wing level training, special exercises, sophisticated training equipment, and extreme weather training.

20 percent to 30 percent of the cost of similar active units. These low ratios stem from the labor (personnel) intensity of Army units. The more capital- (equipment-) intensive aviation units showed much higher cost ratios. The Air Force Reserve units (C-130E and F-4D squadrons) had annual costs of approximately 70 percent of their active counterparts.

The Naval Reserve aviation unit (F-4S squadron) had annual operating and support costs of 54 percent of the cost of the active unit. The analysis of the comparable cost of Navy active and reserve FF1052-class frigates suggests that the reserve ship had annual costs of 86 percent of the active FF1052-class ship. The aggregate level cost results of a number of the case studies are summarized in Table S.1.

The above ratios of reserve to active unit costs do not include the cost of military retirement. Adding military personnel retirement reduces the above ratios slightly; that is, if the cost of military retirement is added to the unit cost estimates, the cost differential between active and reserve units increases. A dual accrual system with separate factors for active and reserve personnel produces larger cost differentials than the single accrual values currently included in the FY 1985 Budget Justifications.

**Table S.1**  
**ANNUAL OPERATING AND SUPPORT COSTS**  
**OF SELECTED CASE STUDY UNITS**  
(\$ FY 1983 million)

Cost Element	C-130E (16 PAA)		Infantry Battalion (ALO 2)		F-4S (12 PAA)		FF1052	
	USAF	ANG	USA	ARNG	USN	USNR	USN	USNR
Personnel-related <sup>a</sup>	21.7	16.4	18.2	3.8	11.2	3.5	8.1	5.1
Equipment-related	18.0	12.4	1.9	0.5	16.4	11.2	9.4	9.9
Total unit cost	39.8	28.8	20.1	4.3	27.6	14.8	17.5	15.0
Ratio <sup>b</sup>	.72		.21		.54		.86	

NOTE: Sums may not add because of rounding.

<sup>a</sup>Does not include the cost of military retirement.

<sup>b</sup>Total cost of the reserve force unit divided by the total cost of the active unit.

## GENERAL OBSERVATIONS

The case studies of aviation and ship units show that the reserve force units have relatively large personnel-related costs. This finding contradicts the conventional notion that a reserve unit's personnel should cost approximately 20 percent of a comparable active unit's personnel, since the reserves are only a part-time force in peacetime. The larger-than-expected reserve force personnel cost is caused by the large number of full-time members of the reserve force unit. These full-time members perform the continuous equipment maintenance and unit support functions that are required in peacetime.

The reserve forces typically realize a cost advantage over the active units in the area of reduced equipment operating requirements in peacetime. The lower peacetime operating levels of reserve force units usually result from the greater experience base and continuity of reserve personnel.

The degree of cost reduction due to lower peacetime operations depends on the ratio of fixed to variable equipment-related costs. For the FF1052 ships, the fixed costs greatly exceed the variable costs of steaming the ship. Thus, the reduced operating tempo of Navy reserve ships contributes relatively little to savings in annual cost. For the aviation units, however, the variable portion of operating cost greatly exceeds the fixed portion. Therefore, the lower peacetime flying program of the reserve units studied substantially affects the difference in annual costs between the active and reserve units.

The case study results suggest that reserve force units typically will have lower annual operating and support costs than their active counterparts at current programmed manning and operating tempos for each type unit. For labor-intensive units, such as those in the Army, the cost may be substantially lower.

The cost analysis described in this report represents an initial, but necessary, quantification of the operating and support costs of comparably equipped active and reserve force units. Alone, however, it will not suffice as a basis for adequately addressing the cost implications of force mix decisions. Additional research in a number of areas is required to provide the complete cost analysis needed for force mix and policy decisions on the structure and operations of reserve force units.

- Nonrecurring activation and deactivation costs.
- Effects on the marginal costs of personnel resulting from different force mix strategies.
- The cost effects of alternative training strategies, maintenance policies, and peacetime operating tempos, intended to maintain capabilities in the presence of changes in the active/reserve balance.

## **ACKNOWLEDGMENTS**

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## GLOSSARY

<b>AFR</b>	Air Force regulation
<b>AGR</b>	active duty guard/reserve (full-time active duty member of reserve unit)
<b>AIMD</b>	Aircraft Intermediate Maintenance Department
<b>AFPCH</b>	Army Force Planning Cost Handbook
<b>ALO</b>	authorized level of organization
<b>AMMO</b>	ammunition
<b>ANG</b>	Air National Guard
<b>ARF</b>	Air Reserve Forces (composed of ANG and USAFR) or Army Reserve Forces (composed of ARNG and USAR)
<b>ARNG</b>	Army National Guard
<b>ART</b>	Air reserve technician or Army reserve technician
<b>AT</b>	Air technician (in USAFR) or Army technician (in USAR and ARNG)
<b>BOS</b>	base operating support
<b>CNA</b>	Center for Naval Analyses
<b>CONUS</b>	continental United States
<b>CORE</b>	Cost-Oriented Resource Estimating (model)
<b>DAAR</b>	Office of the Chief of the Army Reserve
<b>DCNO</b>	Deputy Chief of Naval Operations
<b>DoD</b>	Department of Defense
<b>DS</b>	direct support
<b>FY</b>	fiscal year
<b>GS</b>	general support
<b>MAC</b>	Military Airlift Command
<b>MOS</b>	military occupational specialty
<b>MPA</b>	military personnel appropriation
<b>NCP</b>	normal cost percentage
<b>NGB</b>	National Guard Bureau
<b>OASD</b>	Office of the Assistant Secretary of Defense
<b>OMA</b>	operations and maintenance appropriation
<b>O&amp;S</b>	operations and support
<b>PAA</b>	primary authorized aircraft
<b>PCS</b>	permanent change of station
<b>POL</b>	petroleum, oil, and lubricants
<b>RA</b>	Reserve Affairs
<b>SIMA</b>	Ship Intermediate Maintenance Activity
<b>TAC</b>	Tactical Air Command
<b>TAD</b>	temporary assigned duty

TAR	Training and Administration of Reserves
TO&E	table of organization and equipment
TRADOC	Training and Doctrine Command
UMD	unit manpower document
UPT	undergraduate pilot training
USAFR	United States Air Force Reserve
USAR	United States Army Reserve
USN	United States Navy
USNR	United States Naval Reserve
VAMOSC	Visibility and Management of Operating and Support Costs

## I. INTRODUCTION

The *Total Force* concept underlies all aspects of planning, programming, manning, equipping, and employing the U.S. armed forces. It emphasizes concurrent considerations of both active and reserve forces to determine the most advantageous mix to support national strategy and meet the threat.

The combat readiness of the U.S. armed forces, therefore, depends critically not only on the active components, but also on the successful production of reserve units to meet the readiness standards required for wartime contingencies. Indeed, reserve forces can no longer be regarded as forces in reserve.<sup>1</sup> They constitute adjunct forces that should be integrated as fully as possible into the daily operations of the armed forces.

Faced with an increasingly stringent budget, both the administration and the Congress have focused attention on how the reserve forces could best be used to achieve national defense objectives. As a result, a new Assistant Secretary of Defense for Reserve Affairs was created. In addition, the administration and various military services and agencies have undertaken a series of studies to address issues affecting the reserve components.

Decisions on force mix and resource allocations under the Total Force concept must be informed by a number of considerations, not the least of which is an overarching economic analysis. Numerous past analyses of and reports on the costs of active and reserve force units have attempted to address economy and efficiency while meeting defense requirements.<sup>2</sup> These studies were hampered, however, by the lack of an accepted, consistent costing methodology. The resulting cost estimates, therefore, often contained different levels of detail and encompassed different elements of costs. This deficiency especially affected estimates for the various reserve force components.

The lack of sufficient data across the reserve components of all three services has further hampered such costing efforts. In the absence of a consistent and adequate costing methodology, analysts often relied on convenient, but largely unsubstantiated, rules of thumb in costing reserve units. These cost analysis shortfalls led to

<sup>1</sup>We use the term *reserve forces* in this report to denote both the *reserve components* and the *national guard components* of the *military services*.

<sup>2</sup>Reference 1, pp. II-4 and II-5, lists various studies on active and reserve costs and force mix analysis.

uncertainty regarding the appropriate costs of comparable active and reserve force units. As a result, force mix decisions are often made without adequate knowledge of budget implications.

The cost of change in the active/reserve balance depends on how that change is implemented. For example, in the transfer of equipment from the active to the reserve forces, military capabilities may be held constant or changed, equipment may be transferred without a complete transfer of missions, or new facilities may be required. Also, the activities of seemingly unrelated units may be affected. Each of these factors can imply different unit manning and activity levels, changed flows through formal and on-the-job training, and significant start-up costs.

This report documents a research effort to fill the need for a consistent costing methodology. The research goal was to provide cost analysts with a tool for estimating the annual operating and support costs for both active and reserve components. After developing the methodology, we constructed specific cost models and data bases from selected case studies of Air Force, Army, and Navy units. The results form a body of analytical observations that can be applied to potential cost trade-offs between active and reserve units with particular emphasis on characteristics that drive the cost differences within and between force components.

Cost accounting is a necessary, but not sufficient, set of information for making appropriate force mix decisions. In addition to the cost information, policymakers must also assess the military capabilities of alternative force mixes. Although the active and reserve force units under comparison may have the same types and numbers of equipment, they do not necessarily have equal wartime capability. On the one hand, the greater continuity and experience levels of reserve personnel in some areas may provide a capability advantage over active force personnel. On the other hand, the full-time status of active units may give them a capability advantage over the reserve units, which serve only part-time in peacetime. As pointed out earlier, the force mix entails a multifaceted decisionmaking process, and capability considerations must complement cost analysis. This report deals only with cost.

This costing methodology for active and reserve force units provides a consistent approach to estimating annually recurring operating and support costs. It includes neither the nonrecurring equipment development, procurement, and other investment costs, nor the fixed costs associated with mission and force overhead and the fixed, common use portion of base operating support and training school operations. The cost model contains all the annual costs appropriate to a unit. This

includes all expenditures incurred by one segment of the total force in support of another segment.

The methodology may be used to compare the annual costs of existing units or to estimate the cost implications of minor changes in the mix of active and reserve force units. The models can also be used to estimate the costs of changes in equipment levels and operating tempos, given the effect on personnel requirements of such changes. To address the cost implications of larger force mix changes, the current model must be supplemented by analysis of the nonrecurring costs and the changes in marginal personnel and peacetime operating costs.

We selected several reserve and active units in each of the three services as case studies and developed the necessary factors and the resulting unit operations and support (O&S) cost estimates for these units. The models can be used to estimate the costs for other than case study units, given the appropriate personnel levels and equipment operating and cost factors. The case study results provide useful information about the characteristics of different force components and their implications, from a cost perspective, for the Total Force concept.

Section II of this report describes the general costing methodology: the assumptions, definitions, and general elements of cost included in the analysis. Section III presents the results of various case studies. Section IV contains observations based on the results of the case studies and discusses the characteristics that drive the annual O&S costs and contribute to the differences between the costs of active and reserve force units. Three appendixes provide detail on the development of the model factors for the Air Force, Army, and Navy units.

## **II. COST MODEL OVERVIEW**

The basic research objective was to develop a method, including a model and case study examples, for estimating unit-level operations and support costs—a method that could adequately compare costs across the different components of the force. The first phase of the research concentrated on developing a general cost-estimating approach. This section describes the desired characteristics of the estimation method, enumerates the assumptions, and defines the terms used and the nature of the costs. It also describes the resulting O&S cost model and lists, with explanation, the elements of costs considered.

### **MODEL GUIDELINES AND DEFINITIONS**

#### **Desired Characteristics**

Three qualities that we deemed important—consistency, inclusiveness, and availability of comparable data—guided the overall development of the cost-estimating model. First, to provide useful comparisons, the model must take a consistent approach across all services and components. Therefore, we used the same types and categories of cost across services and components and, whenever possible, the same or similar data sources and derivation methods to develop the various personnel and cost factors. While services and components have some unique cost elements, the basic core of the cost-estimating approach remains general and consistent. This characteristic helps to ensure that meaningful comparisons may be made across services and across the components of each service.

Second, the model must produce inclusive unit cost estimates. That is, it must consider all recurring operating costs appropriate to a unit, including any costs incurred by one segment of the total force in support of another segment. For example, the operations of training schools and the procurement of replacement spare parts for reserve components are reflected in the active force budgets. The model allocates an appropriate share of these costs to the reserve and guard units.

Finally, the factors contained in the model are derived mainly from official service sources and may be easily updated. This study did not seek to collect and construct original data, but rather to use existing

data sources and factors wherever possible. The availability of data varied across services and components and, in some instances, we developed factors by collecting on-site data or by manipulating more aggregate costs to approximate the factors necessary for the unit cost estimation. As an important result, the study identified data improvements needed to strengthen the cost analysis of active and reserve units.

### Comparable Units

To form meaningful comparisons, the model estimates costs for *comparable* units in the active, reserve, and national guard components of each service. Comparable units are defined as being similarly manned and equipped and having similar wartime missions. Similar manning and equipping should not be interpreted as implying comparable capability. Many factors affect capability and must be considered in making comparisons. Factors include the mission of the units, the experience base of the units, and the available diversity of training opportunities.

Personnel costs are based on the wartime manpower authorization statements for the units. Similar units in different components of a service may have the same wartime personnel requirements in terms of numbers of people. However, one difference between active and reserve units is the full-time/part-time mix of personnel in peacetime. Although the reserves are a part-time force in peacetime, they require some full-time personnel to maintain equipment and provide unit support functions. Also, active units may have reserve augmentees to cover duties or extra workloads that will exist in wartime but are not present in peacetime. The peacetime costs of the appropriate mix of unit personnel are included in the cost estimates.

Unit manpower authorization levels, rather than the actual unit personnel strengths, are costed. The programmed levels of unit personnel are used to represent the cost of average units and to overcome any personnel constraints due to budget problems. Therefore, the cost estimates assume the absence of unit manpower shortfalls and surpluses. In most of the cases examined, active and reserve units were manned at, or near, full authorization levels. However, personnel shortfalls may exist in certain types of units because of skill-related deficiencies, demographic constraints, or budget problems.

The units are also assumed to have the same numbers and types of equipment. For ships and aircraft squadrons, this assumption is generally true. For certain types of support units, however, budget con-

straints and equipment shortfalls may cause some difference in equipment allocations between active and reserve units.

Comparable units should also have similar wartime missions. Such a match may not be strictly possible, however, since a reserve unit may not have the full range of operational requirements that an active unit has. For example, reserve tactical air squadrons lack nuclear weapons delivery missions. However, reserve units often have large numbers of prior-service personnel who have received active duty training in the types of missions lacking in the reserve unit's required wartime capabilities. Also, reserve units may follow later deployment schedules, allowing some time for additional training.

#### **Cost Definitions and Assumptions**

The study objective was to estimate the *annual recurring* operating and support costs of a unit. These cost estimates represent the steady state costs of existing units on existing bases. They include annual replacement costs of personnel and equipment parts, as well as a portion of the peacetime base support costs. They do not include the costs of equipment development and procurement, construction of facilities, base opening package, and the initial training of the unit personnel.

The costs are estimated on a *variable* or *incremental* basis; that is, only the costs related directly to the unit's annual operations are estimated. Overhead force-wide costs related to the administration of the entire force or component are not included, nor are the fixed, common use portions of base operating support (the base opening package) or the fixed costs of school training. These costs are assumed to be relatively insensitive to small changes in the number of units in the force or to the number located on a specific base. Therefore, the resulting cost estimates are appropriate for small changes to the current mix of active and reserve units, but may underestimate the costs of large changes to the force structure.

Costs are estimated for *typical* or *notional* units based in the continental United States (CONUS). Specific units may have larger or smaller costs because of operating location, variances in grade structure, or other factors peculiar to a single, actual unit. The estimates, however, represent the costs of average units in a component of the force.

The cost estimates are based on a "snapshot" of the current force and the flows of personnel between components of the force. As the force structure changes or as economic conditions affect the flow of personnel into, out of, and between the active and reserve components,

certain elements of personnel cost will change. This statement applies especially to the school training cost of replacement personnel. Changes in personnel flows between active and reserve units will increase or decrease the number of prior-service recruits in reserve units, thereby decreasing or increasing replacement training costs.

Finally, all costs are expressed in FY-1983 dollars. Data in other year dollars were converted to the FY-1983 base using published, service-generated indexes.

### MODEL DEVELOPMENT

Based on the general guidelines and definitions described above, we interviewed the various budget, comptroller, and cost analysis organizations in each service to find out what models, factors, and data sources were available for estimating annual O&S costs at the unit level. We then modified existing models and cost-estimating procedures to align with the general objectives of the analysis. These modifications typically involved incorporating the costs of the unique features of reserve unit operations.

The initial cost-estimating models for each service were then fine-tuned by the analysis of specific case study units. A substantial portion of the case study analyses was devoted to the development of the personnel and equipment factors needed to estimate unit O&S costs. The overriding consideration during the factor development was maintaining consistency across the service components. We discussed the development of the necessary factors with numerous service organizations, including manpower, training, and operations groups.

With the completion of the case study analysis for each service, the service-unique models were then reviewed and modified to maintain consistency across all three services. This step in the development process was aided by comments from service and component organizations on the adequacy and accuracy of the initial models and data factors. The primary concern during this step was to develop the personnel and equipment factors on a consistent basis across all services and service components.

### MODEL OVERVIEW<sup>1</sup>

The total annual O&S costs for a unit are usually divided into three major categories—the cost of unit personnel, the cost of operating unit

<sup>1</sup>The specific cost-estimating equations contained in the model and the development of the necessary data factors are contained in the appendixes.

equipment, and the support cost of the peacetime operating location. The *unit personnel cost* includes the following elements:

- Pay and allowances
- Aquisition and training of replacement personnel
- Other (including travel, bonuses, death gratuities, and medical)
- Military retirement.

*Equipment operations* include:

- Petroleum, oil, and lubricants
- Training ordnance
- Maintenance supplies
- Replenishment spare parts
- Depot-level maintenance
- Other, higher-level maintenance
- Other equipment costs (including modifications and replacement support equipment).

*Base support* includes:

- Base operating support, medical support, and real property maintenance personnel.
- Nonpersonnel support costs (including rent, utilities, communications, and data processing).

Only two main categories are used in the model: personnel-related costs and equipment operating costs. The model aggregates the base support costs by combining the support personnel with the unit personnel to arrive at *total personnel* and by treating the other elements of support cost (rentals, utilities, etc.) as an average cost per person (termed *BOS-nonpay*).<sup>2</sup>

The model estimates the cost elements by using various factors in simple linear equations. The four basic sets of factors include:

- Personnel strengths (the number and types of people associated with the unit or base support functions)
- Per capita costs (the average costs per person for the different elements of personnel cost)
- Equipment quantity and operating rates (the programmed peacetime operating times for unit equipment)

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<sup>2</sup>Although the model attempts to estimate the variable costs due to having an additional unit stationed on a base, it is currently not always possible to separate the fixed portion from the variable portion of the base operating expenses. Therefore, the BOS-nonpay factor may include both fixed and variable costs.

- Equipment costs (the fixed and variable cost factors for the different categories of equipment cost).

### **Personnel-Related Costs**

Personnel-related costs are broken into four cost elements: pay and allowances, replacement acquisition and training, other personnel costs, and military retirement. To obtain costs for each element, we usually multiplied costs per person in each personnel category (per capita factors) by the number of people in that category (personnel strengths). We then summed the cost elements to arrive at total personnel-related costs.

**Personnel Categories.** Costs are estimated for the unit and corresponding base support personnel. These include the personnel concerned with equipment operations, unit-level maintenance, administration, security, base operating support, real property maintenance, and medical support. The model divides unit and support personnel into several categories and subcategories.

First, the model distinguishes between officer and enlisted personnel. These two categories are further broken down for aviation units into rated (or aircrew) and nonrated (or ground) personnel. This distinction is needed to account for the additional flight pay of rated personnel and the difference in training costs. Among the rated members of an aviation unit, pilots are segregated from other aircrew members because of the large cost of training pilots. Finally, the supervisory members of the unit who have ratings and therefore receive flight pay are also distinguished from other normal flight crew members.

Second, the model distinguishes between full-time and part-time personnel. For active Air Force and Army units, the full-time military complement is based on wartime requirements. These units have only full-time, active-duty members. For active Navy units, however, the full-time military complement represents the personnel needed for normal peacetime operations. Because the increased wartime operating tempo requires additional personnel, each active unit has a Selected Reserve augmentation. These reserve augmentees usually train with their (or a similar) active unit during some annual training periods. Active Navy units, therefore, have both full-time and part-time members.

Although reserve units are a part-time force in peacetime, all have some number of full-time personnel. The full-time members provide the continuing equipment maintenance and administrative support needed for peacetime operations.

The full-time members of reserve force units fall into several categories. Activated, or full-time, reservists in the Navy are termed TARs (Training and Administration of Reserves); in the Army Reserve (USAR), Army National Guard (ARNG), and the United States Air Force Reserve (USAFR), they are called AGRs (active guard/reserves). Another full-time reserve category includes civilians who work during the week for the reserve unit but are also military members of the unit. These full-time personnel are termed ATs (Air technicians) in the Air National Guard (ANG), ARTs (Air reserve technicians) in the USAFR, and ATs (Army technicians) in the USAR. Finally, USNR ships will have full-time active Navy (USN) personnel to cover shortfalls in ratings in the TAR community.

Finally, the model distinguishes between civilian technicians and the civilians employed in the unit or in base support functions. These personnel receive average civilian pay and allowances only.

The number of personnel in each of these categories is derived from service documents showing the unit personnel authorizations. The model assumes that the unit is staffed to the specified authorization level and has the full allotment of personnel.

**Personnel Pay and Allowances.** Pay and allowances are calculated for the different categories of personnel. The category includes basic pay, allowance for quarters, subsistence, variable housing allowance, incentive pay, flight pay, hazardous duty pay, special pays, sea pay, clothing allowance, family separation allowance, separation payments, and social security tax payments. The pay and allowance cost factors are derived from budget documents and are based on service and component averages for the different categories of personnel. Civilian pay and allowance factors also include that portion of retirement costs contributed by the federal government.

**Other Personnel Costs.** Other personnel benefits not included under pay and allowances are included under this category. In general, the category includes the costs for travel, permanent change of station (PCS), death gratuities, hospitalization, medical supplies and equipment, disability, reenlistment bonuses, and a share of support costs, such as rentals, utilities, communications, and computer operations. These are average officer and enlisted per capita factors that vary by service components, but not by unit. The costs are derived from either service documents or the Budget Justifications.<sup>3</sup>

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<sup>3</sup>The Budget Justifications are published annually by each service component to provide the Congress with detail on the monetary outlays by budget item. The Personnel Budget Justifications and the Operations and Maintenance Budget Justifications for each service component were used to develop various per capita factors. (See Refs. 2-17.)

When estimating support costs it was not possible to adequately separate fixed from variable base operating support costs or to separate equipment-related support costs from personnel-related support costs. We therefore aggregated the various types of support-related costs into a single personnel factor. As better data become available in this area, they should be incorporated into the cost-estimating methodology.

**Replacement Acquisition and Training Costs.** The model does not include the initial, one-time cost of training all the unit personnel, since it estimates only annual recurring costs. It does, however, include the cost of recruiting and training personnel to replace those who left the unit during the year. This cost element is based on (1) the cost to recruit and train an individual sufficiently to receive a speciality code and join a unit and (2) the number of individuals in a unit who must be replaced.

The acquisition and training cost of an individual will vary across the skills required in a unit. For example, it costs significantly more to train a pilot than a maintenance person or an administrative/clerical worker. For this reason, training costs are calculated for pilots, other aircrew members, and other unit personnel (general skill). However, within these categories, the cost to train active and reserve personnel is assumed to be equal, since all receive the same training at the same schools. Therefore, the replacement training costs for similar active and reserve units will differ only by the number of personnel who require training.

The cost factors include the costs of recruiting, basic recruit training, initial skill training, and any other formal schooling required before a person can join a unit. The factors also include the pay and allowances of recruiters, trainers, and students, the travel to and from training installations, recruitment advertising, the books and other materials required for classroom instruction, and any equipment operating cost, including munitions, involved in the training programs. The training cost factors are based on the number of graduates and, therefore, include the effects of any personnel attrition during training.

We obtained the various skill-group training-cost factors from published sources or from the service training commands. The accuracy and quality of the factors varies across the services and within skill categories of the individual services. For example, the expensive pilot training costs are more closely tracked and documented than the costs of training clerks or other less costly skills.

The number of replacements that must be trained is a function of the turnover rate within a skill group and the proportion of that turnover that is filled with nonprior-service personnel. Since the reserve force recruits a large number of prior-service individuals who were

trained during an active service career, some replacement personnel in reserve units will not require the recruit and initial skill training. These prior-service gains by the reserve force, along with higher retention rates, help reduce the replacement acquisition and training costs of reserve units.

Turnover factors are based on the personnel losses of each service component. We divided the losses reported in the Budget Justifications (less reenlistment gains) by average personnel strengths to estimate personnel turnover. For reserve components, the turnover factor was further multiplied by the percentage of personnel gains that were nonprior service. Because aircrew training is so expensive, pilot and other aircrew turnover factors were based on the number of graduates from the training pipelines divided by the appropriate aircrew populations. For example, if 10 fighter pilots were trained for the reserve force and there were 100 pilots in reserve fighter units, we estimated the turnover rate as 10 percent.

**Other Training Costs.** The cost of the normal active and inactive drill periods for reserve personnel is included under pay and allowances. However, reserve personnel often have additional paid days for other types of unit and personnel training. These include refresher and proficiency training of prior-service personnel, career development classes, and other events and activities that prepare the units or individuals for their service missions.

The cost of these additional training days, primarily pay and allowances, are included under other training costs. Since active duty personnel are paid for the complete year and have no additional paid days, the other training costs category refers only to reserve units. The per capita cost factors for this category were developed by prorating the costs contained in the Budget Justifications over average personnel strengths.

**Retirement.** The civilian pay and allowance factors include a government retirement fund contribution equal to 7 percent of basic pay. However, the military pay and allowance cost factors do not include the future cost liability of retirement.

The cost of military retirement has always been an unfunded liability to the federal budget. No funds have ever been set aside for future retirement costs; rather, budgets have contained only the costs of current retirement benefits. However, under recent legislation (Public Law 98-94) the Department of Defense must fund the military retirement system on an actuarially sound basis using an aggregate entry-age normal approach. Starting with the FY-1985 budget, each military service will include a charge for accruing future retirement liabilities in its personnel budget.

The annual retirement accrual charge is expressed as a percentage of total military personnel basic pay. Termed the *normal cost percentage* (NCP), it is calculated by the DoD Office of the Actuary using several analytical models [18]. The models accept numerous factors describing both the flow of personnel through the force and the assumptions on future economic conditions. For FY 1985, the single NCP calculated by the DoD Actuary across all services and components is 50.7 percent. Therefore, in the FY-1985 budgets, retirement benefit additives are costed at 50.7 percent of basic pay.

The problem with a single NCP across the total force is that the active and reserve retirement systems differ considerably. Basically, active personnel receive immediate payments upon retirement after 20 or more years of service. Benefits are based on the individual's current or recent pay rate and length of service. Retired reserve personnel do not receive benefits until age 60; the amount of payment is based on the active pay scale adjusted by the number of points the reservist has earned during his or her service career.

Because of the difference in the two systems, some DoD offices have suggested that retirement should be funded on a dual accrual basis—separate NCPs for the active and reserve forces. Using the same assumptions and techniques as those used to calculate the force-wide NCP, a dual accrual approach yields an NCP of 52.2 percent for active personnel and 8.1 percent for reserve personnel [19].

The question of how to cost future retirement liabilities presents difficulties. The system could be funded in an infinite number of ways, of which the aggregate entry-age normal is but one. Even the calculation of the Normal Cost Percentage depends greatly on several assumptions, including nominal interest rates, inflation rates, annual growth in military pay, final pay grades, continuation (reenlistment) rates, and the percentage of the force that reaches retirement. Some of these factors are common across the active and reserve forces; others are unique to each component. Resulting NCPs can vary by as much as 100 percent, depending on the assumptions used.

In addition to the problems surrounding the future cost of military retirement, the question arises of whether the 7 percent factor for civilian retirement adequately reflects the future cost of civil service retirement benefits. In the present study, this question does not affect the Army and Navy, since the units studied had no, or relatively few, civilian employees. The case study units in the Air Force reserve components, especially the Air National Guard, had a large number of civilians. If the 7 percent factor does not represent a sufficient estimate of the future cost of civilian retirement, the resulting unit costs will be biased downward.

The above questions are beyond the scope of this analysis and require substantial research efforts. In the approach used here to estimate annual unit O&S costs, we calculated military retirement benefits separately from other costs, based on the single and dual accrual percentages of the DoD Office of the Actuary. The resulting unit costs are presented for three cases—without retirement, with retirement benefits calculated at 50.7 percent, and with retirement benefits based on the dual accrual percentages of 52.2 percent for the active and 8.1 percent for the reserve forces.

#### **Equipment-Related Costs**

The estimation of personnel-related costs is consistent across the various services and components, with similar data sources and derivation techniques used to develop the per capita factors. The development of the unit equipment-related costs, however, varies across the services, owing to large variances in data quantity and quality. In some cases, equipment operating hours and specific operating-cost factors are readily available or can be developed from published data. At the other extreme, little or no data are available and the equipment costs are based on aggregate data collected from specific units.

This subsection describes the general, *ideal* approach to estimating equipment-related costs. The specific case studies presented in Sec. III describe the different approaches for the various services and components.

**Fixed Versus Variable Costs.** The total equipment-operation and maintenance cost contains both fixed elements, depending only on the numbers and types of equipment, and variable elements that are a function of the peacetime operating tempo of the unit.<sup>4</sup> For example, scheduled depot-level maintenance for aircraft and ship overhauls are programmed on a calendar basis independent of the operating levels between the maintenance actions. These elements of cost are fixed.

Some fixed elements of cost, such as programmed depot-level maintenance, are the same for active and reserve units. Other fixed elements of cost, such as training ordnance, may differ for active and reserve force units. In contrast, fuel consumption depends on how often the equipment is used. Therefore, fuel represents a variable element of operating cost that usually differs for active and reserve units because the levels of peacetime equipment operations differ.

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<sup>4</sup>The cost of maintenance personnel assigned to the unit (either organizational or intermediate maintenance) are included in the personnel-related costs.

The methodology for estimating the various components of equipment-operating cost involves combining the fixed and/or variable cost factors with equipment levels and programmed peacetime usage. As mentioned above, the data used to estimate costs in this fashion varied by service.

The Air Force publishes fixed and variable cost factors and programmed flying hours for various aircraft types. The Navy publishes programmed operating tempos for aircraft and ships, but we had to develop the cost factors from operating and support cost collection systems. The Army has no programmed operating tempos for equipment (other than aircraft) and no adequate cost reporting system. Army equipment operating costs were, therefore, developed from unit-specific data collection.

**Peacetime Equipment Operations.** The variable portion of equipment operating costs is based on the programmed use of the unit equipment in peacetime. The planned flying hours per aircraft per year are used for Air Force and Navy aviation units, and planned steaming hours per year are used for Navy ships. Programmed hours are costed instead of actual peacetime experience for the same reasons that authorized personnel levels are used for personnel-related costs. Actual times may reflect budget shortfalls or responses to unplanned crises. To cost average units at the levels of peacetime operations sought by the services, we based the unit equipment cost estimates on programmed peacetime usage.

**Petroleum, Oil, and Lubricants (POL).** The fuel used by unit equipment during programmed peacetime operations is a variable element of cost. It is estimated by applying POL cost per hour or mile to the programmed hours or miles of usage.

**Training Ordnance.** The cost of ammunition, bombs, missiles, and other ordnance expended during training practice is a fixed element of cost. It may vary by service component.

**Maintenance Supplies.** This category covers the consumable items used during equipment maintenance at either the organizational or intermediate levels of maintenance. It includes such items as gaskets, seals, and filters needed for preventive or corrective maintenance. Depending on the service, this element of cost may have a variable, or a fixed and variable component.

**Replenishment Spare Parts.** Where maintenance supplies includes rather inexpensive, consumable maintenance items, this category includes the more costly subsystem components that must be replaced because of wear or condemnation. This element of cost is generally variable, depending on only the equipment-operating levels.

**Depot-Level Maintenance.** This element of cost includes the labor and material expended during the depot maintenance or overhaul of unit equipment. Certain equipment, such as ships and airframes, are scheduled for depot maintenance on a calendar basis. This portion of depot cost is therefore fixed. Engines and avionic components are often sent to the depot because the level of repair is beyond the capability of the organizational or intermediate maintenance levels. This portion of depot maintenance is unscheduled and, therefore, variable. Total depot maintenance cost is generally based on the numbers and types of unit equipment, the programmed peacetime equipment usage, and fixed and variable cost factors.

**Other, Higher-Level Maintenance.** This category covers the cost of maintenance above the unit level but below the depot level, primarily, the labor and material expended by the direct support (DS) and general support (GS) maintenance units that service Army maneuver battalions. It also includes the ship intermediate maintenance activities (SIMA) in the Navy. This cost element may have both fixed and variable components.

**Other Equipment Costs.** This category covers any other elements of cost that can be measured for a unit's equipment operations. It includes modifications, replacement support equipment, and ship utilities. These costs are measured by applying a fixed cost factor to the number and/or cost of the unit equipment. This category contains no costs for Army units.

#### **RELATED ISSUES**

This study deals solely with costs, making no assumptions about the wartime capability of the units. Active and reserve units differ in peacetime, and these differences affect not only the annual O&S costs, but also the unit's wartime capability. The reserve is a part-time force in peacetime and reserve units typically operate their equipment less frequently. However, they may have a large cadre of full-time personnel, such as in the ship and aircraft communities. Reserve units also have large numbers of experienced, prior-service personnel who remain with the unit for long periods. This continuity and base of experience help maintain the readiness and wartime capability of reserve units.

Force mix decisions must consider both the costs and the wartime capabilities, and the trade-offs between them. Other important decision variables are the peacetime rotation base, deployment schedules, and legislative constraints. The comparison of annual O&S costs should not be the sole criterion in mix decisions.

The model does not allocate to the reserve units training costs incurred by the active force for prior-service personnel who join the reserve. The reserve, therefore, realizes a cost benefit in recruiting prior-service individuals (and the total force benefits from retaining trained personnel). Also, no costs for the mission or administrative functions provided by the active force are allocated to reserve units. The cost of administering the total force is not included in the model for either active or reserve units.

Finally, the model ignores certain elements of cost associated with the activation or deactivation of units. These elements include construction of new facilities or disposal of existing facilities, increased recruiting and training efforts to support a new unit, and active unit shutdown costs, such as the transportation of personnel and equipment and the deactivation (mothballing) of equipment.

### **III. CASE STUDY RESULTS**

The general model outlined in Sec. II provides a framework for estimating the annual operating and support costs of units. To adapt the general framework to specific services and components, we analyzed several case studies.

This section presents the results of comparing the annual O&S costs for similar units in the active and reserve components of the Air Force, Army, and Navy. For each service, we present the estimating methodology, a description of the data factors, and the annual O&S cost estimates. Summary comments are also included to put the results into perspective and to identify areas of cost in which active and reserve units differ.

A significant portion of the overall research was devoted to developing the necessary personnel and equipment factors used in the cost-estimating equations. In some cases, factors for active units were available; in almost all cases, factors for reserve personnel were unavailable. To maintain consistency across components, we developed active and reserve factors on a common basis from the same or similar data sources. The development of the various factors, along with the sources and derivation techniques, are contained in three technical appendixes (one for each service) to this report.

#### **SELECTION OF UNITS FOR STUDY**

The cost-estimating models were applied to a number of case studies in the different military services.<sup>1</sup> The case studies include the following types of units:

Air Force

- F-4D squadron (24 and 18 aircraft)
- C-130E squadron (16 and 8 aircraft)

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<sup>1</sup>We made no case studies of Marine Corps units. The Center for Naval Analyses (CNA) investigated the comparable costs of active and reserve Marine infantry and helicopter units [20]. The cost-estimating methodology used by CNA and the resulting reserve to active cost ratios were very similar to the methodology and results of our analysis. To avoid duplication of effort, Marine Corps units were not included in our analysis.

**Army**

- Mechanized infantry battalion
- Armor battalion (M60A3)
- Field artillery battalion (155mm, self-propelled)
- Combat engineer battalion

**Navy**

- F-4S squadron (12 aircraft)
- FF1052 frigate

The main criterion for selecting specific unit types for analysis was that the type existed in both the active and reserve forces. Although the recent interest in the reserve forces has led to the introduction of new, front-line equipment in reserve units, heretofore the reserve forces typically received equipment that had been phased out of the active force. Therefore, until the early 1980s, relatively few types of units were common across a given branch of the military services. Once a list of candidate units was identified, specific types of units were chosen based on guidance from the staff of the Office of the Assistant Secretary of Defense (Reserve Affairs)—OASD(RA).

The units chosen for the case studies are all combat-oriented. Costs were not estimated for support-type units. The active/reserve cost comparisons resulting from the case study analysis may not reflect the differences for support units.

Although specific data factors were developed for only the units listed above, the models can be used to estimate costs for any type of unit. Some model factors, including the average pay and allowance factors, should apply across all units. Other factors, including personnel levels and equipment-operating tempos, depend on the unit. Once the necessary unit-specific factors are developed (the appendixes describe the derivation of all model factors), the models can generate annual O&S cost estimates.

**AIR FORCE**

The Cost-Oriented Resource Estimating (CORE) model contained in AFR 173-13 [21] was designed to estimate the annual operating and support costs of active units. Because the CORE model estimates annual unit cost on the same basis as the methodology adopted for the

present analysis, we used it as the basis for estimating the O&S costs of similar units in the active Air Force and Air Reserve Forces (ARF).<sup>2</sup>

Because it was developed for active units, the CORE model required slight modification to accommodate the special characteristics of ARF units. We added the "other" training cost element for the additional ARF training periods for refresher/proficiency training, career development, and other unit or personnel training over and above the normal active and inactive drill periods.

A second modification to the CORE model was the inclusion of various peacetime basing options. Active squadrons are almost always located on active bases, and the CORE model includes the cost of variable base operating support, real property maintenance, and medical support personnel at active bases. The ARF units, especially the Air National Guard, are often based at commercial airports. To allow for various peacetime basing options for ARF units, support personnel are included for units on active, USAFR, ANG, or commercial airfields.

The final modification to the CORE model involved the cost factors used for pilot and other aircrew training. The CORE model factors cover only the costs of undergraduate pilot training (UPT) and the initial courses for other aircrew members. Based on cost data received from the Tactical Air Command (TAC) and the Military Airlift Command (MAC), we extended the CORE model cost factors to include all the flight and school training required before an aircrew member is assigned to a unit.

### **Personnel Categories**

The squadron personnel are segregated into four functional areas—aircrew, administrative/staff, maintenance, and weapon system security. The maintenance personnel include both organizational-level maintenance and an appropriate share of wing intermediate-level maintenance. Aircrew members are further divided into pilots, other officer aircrew, and enlisted aircrew. The aircrew, or rated personnel, receive additional flight pay over and above the normal pay of non-rated, or ground, personnel.

Officer, enlisted, and civilian personnel are identified for each functional category. Also included are the various types of full-time personnel associated with ARF units. These include Air technicians (ATs) in the ANG and Air reserve technicians (ARTs) and full-time reserves (AGR)s in the USAFR. The ATs and ARTs are paid for both

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<sup>2</sup>The ARF includes the United States Air Force Reserve (USAFR) and the Air National Guard (ANG).

their military and civilian duties. The AGRs are paid on the same basis as active force personnel.

### Data Sources

In addition to the CORE model, Ref. 21 contains various active personnel cost, squadron personnel strength, and equipment-operating-cost factors for Air Force aircraft. Only a limited number of ARF-related factors are included in Ref. 21. We therefore had to develop most ARF factors from other data sources. To ensure consistency across the components, active factors were also developed from the same or similar data sources; if the results differed significantly from the active factors contained in Ref. 21, the former were used in the cost analysis.

The Air Force provided a listing of units and their associated bases for the various F-4D and C-130E active and ARF squadrons. We obtained unit manpower documents (UMDs) for each base to identify the numbers and types of personnel in the various functional areas of the unit. The UMDs provided the personnel strengths for the USAFR and ANG units. The values for active units contained in Ref. 21 closely matched the UMD figures, and we used them as the measure of active squadron personnel strengths.

The per capita cost factors were developed primarily from information contained in the FY-1985 active and ARF Personnel Budget Justifications [2-4] and Operations and Maintenance Budget Justifications [5-7]. Training costs are based on Ref. 21, plus information received from TAC and MAC. Since active and ARF personnel attend the same courses in the same schools, the cost per student for the various categories of skills is the same across all components.

The turnover factors for aircrew members, or the number of aircrew personnel in the squadron who must be trained each year, are based on information from the Air Training Command and the training organizations of the USAFR and ANG and Ref. 22. For non-aircrew personnel, turnover factors are based on losses from the service component (from the Personnel Budget Justifications) tempered, for ARF units, by prior-service gains.

Programmed operating levels for active and ARF F-4Ds and C-130Es were provided by Ref. 23. The various aircraft operating cost factors are contained in Ref. 21. Except for fuel (POL) use, separate cost factors do not exist for ARF aircraft. Therefore, we assumed that the cost per aircraft or per flying hour was the same (except for POL) for active and ARF aircraft.

## Results

Tables 1 and 2 show the resulting annual O&S cost estimates for a C-130E squadron with 16 primary authorized aircraft (PAA) and an F-4D squadron with 24 PAA, respectively.<sup>3</sup> The case study results for the two types of units show similar results: the ARF units have annual O&S costs of approximately 70 percent (without retirement) of their active counterparts.

Typically, ARF aircrews, because of their greater experience and the fact that many ARF aircrew members hold comparable civilian positions with commercial airlines, require fewer peacetime training flights than active pilots. Therefore, for similar missions and units with the same number of aircrews, an ARF squadron will have lower annual equipment operating costs than an active unit. In the C-130E and F-4D units, the ARF aircraft fly 36 percent (ANG C-130E) to 20 percent (USAFR F-4D) fewer hours than active units, resulting in a comparable reduction in aircraft operating costs. However, if the peacetime mission dictates a larger number of flights or if an ARF unit has more aircrews than the active units, the ARF unit's equipment operating cost begins to approach that of an active squadron.<sup>4</sup>

Reserve force units, because of their part-time operations in peacetime, are popularly believed to have much lower personnel-related costs than active units. However, Tables 1 and 2 show ARF unit personnel-related costs to be 65 percent to 75 percent of the comparable active unit's personnel cost. Two factors drive ARF personnel costs to these higher-than-expected levels: Manpower levels differ across similar active, USAFR, and ANG units, and ARF units have large numbers of full-time personnel for unit administration, equipment maintenance, and base support functions. The total mission personnel requirements and the number of full-time positions is displayed in Table 3 for the F-4D and C-130E case studies.

The military personnel requirements for ARF units differ from those of active units for a number of reasons. The administrative staff requirements for ARF units are determined by ARF headquarters, based on recommendations by personnel planners in the active force. Because of the dispersed basing mode of ARF squadrons, typically a single squadron per base, the reserve organizational structure requires either a group or wing headquarters for each of its squadrons. This

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<sup>3</sup>Analyses of 18 PAA F-4D and 8 PAA C-130E units are contained in Appendix A (Tables A.22 and A.23).

<sup>4</sup>The fighter intercept (F-106) and strategic tanker (KC-135) missions exemplify this cost effect of extended ARF squadron peacetime operations. Unpublished Rand research suggests that the O&S cost ratio of ARF to active units for intercept and strategic tanker missions is close to or above 1.

**Table 1**  
**AIR FORCE UNIT OPERATING AND SUPPORT COSTS**  
**C-130E, PAA 16**  
**(\$ FY 1983 million)**

	USAF	ANG	Ratio <sup>a</sup>
<b>Personnel</b>			
Unit pay and allowances			
Officer--part-time	0	1.10	
Officer--full-time	4.39	0	
Enlisted--part-time	0	1.43	
Enlisted--full-time	6.97	0	
Civilian	0.13	6.87	
Total	11.49	9.40	0.82
Other unit personnel costs			
Officer	0.50	0.23	
Enlisted	1.50	0.82	
Civilian	0.03	0.13	
Total	2.03	1.18	0.58
Unit acquisition and training costs			
Pilot	4.19	1.67	
Aircrew	1.53	0.75	
Non-aircrew	0.69	0.29	
Other reserve	0	0.51	
Total	6.41	3.22	0.50
Support personnel costs	1.79	2.59	1.45
Total personnel costs	21.72	16.39	0.75
<b>Equipment</b>			
POL	9.08	5.54	
Maintenance supplies	1.58	1.15	
Replenishment spares	2.50	1.60	
Replacement support equipment	0.52	0.52	
Depot maintenance	3.68	2.90	
Modifications	0.68	0.68	
Ordnance	0	0	
Total equipment costs	18.04	12.40	0.69
Total unit costs	39.76	28.79	0.72

NOTE: USAF units are located on active bases. ANG units are located on commercial bases. Sums may not add because of rounding.

<sup>a</sup>Reserve cost divided by active cost.

**Table 2**  
**AIR FORCE UNIT OPERATING AND SUPPORT COSTS**  
**F-4D, PAA 24**  
**(\$ FY 1983 million)**

	USAF	USAFR	Ratio <sup>a</sup>	ANG	Ratio
<b>Personnel</b>					
Unit pay and allowances					
Officer--part-time	0	0.76	0.79		
Officer--full-time	3.27	0	0		
Enlisted--part-time	0	1.73	1.51		
Enlisted--full-time	10.05	0	0		
Civilian	0	7.78	6.52		
Total	13.32	10.27	0.77	8.82	0.66
Other unit personnel costs					
Officer	0.38	0.10	0.18		
Enlisted	2.19	0.62	0.95		
Civilian	0	0.13	0.12		
Total	2.57	0.85	0.33	1.25	0.49
Unit acquisition and training costs					
Pilot	3.25	0.74	1.32		
Aircrew	1.93	0.61	1.57		
Non-aircrew	1.16	0.71	0.38		
Other reserve	0	0.64	0.44		
Total	6.33	2.70	0.43	3.71	0.59
Support personnel costs	2.81	0.59	0.21	3.07	1.09
Total personnel costs	25.03	14.41	0.58	16.85	0.67
<b>Equipment</b>					
POL	10.49	7.47	6.62		
Maintenance supplies	1.66	1.38	1.24		
Replenishment spares	1.95	1.56	1.38		
Replacement support equipment	1.21	1.21	1.21		
Depot maintenance	4.20	3.83	3.66		
Modifications	0.85	0.85	0.85		
Ordnance	2.06	2.06	2.06		
Total equipment costs	22.41	18.35	0.82	17.01	0.76
Total unit costs	47.44	32.76	0.69	33.86	0.71

NOTE: USAF and USAFR units are colocated on active bases. ANG units are located on commercial bases. Sums may not add because of rounding.

<sup>a</sup>Reserve cost divided by active cost.

contrasts with the consolidated basing of most active squadrons, in which a wing headquarters commands typically three colocated squadrons. The diseconomies associated with the ARF unit dispersal raise the staff personnel levels.

The military maintenance manpower requirements for USAFR units are dictated by the active force. Almost always, these requirements are higher than those of a comparable active unit. The reason for this is

unclear, although in the past, a different wartime availability (a lower man-hour work week) was used in the ARF personnel calculations.

The active also stipulates maintenance manpower requirements for Air National Guard units. However, the guard has resisted manning to the active's specifications and generates its own military maintenance manpower requirements. As a result, ANG squadrons usually have fewer maintenance personnel than USAFR squadrons and, in some cases, the guard may have a smaller maintenance complement than the comparable active unit.

The USAFR and the ANG determine full-time (ART, AT, and AGR) maintenance personnel for their own aircraft units. These personnel levels are a function of the maintenance man-hours per flying hour for the specific aircraft and the number of peacetime flying hours (with constraints dictated by personnel ceilings).

For most Air Force aircraft units, whether active, USAFR, or ANG, equipment-related costs represent approximately half of total unit O&S costs. Because the number of full-time technicians is driven by the peacetime flying operations, the costs related to equipment operation are even larger for ARF squadrons than the ratios indicated by the total equipment costs in Tables 1 and 2.

## ARMY

The *Army Force Planning Cost Handbook* (AFPCH) [24] contains total recurring and nonrecurring investment and annual operating costs for various Army active units. It also contains the model structure used to generate the unit cost estimates and some active per capita

Table 3  
AIR FORCE MISSION PERSONNEL REQUIREMENTS

	F-4D, 24 PAA			C-130E, 16 PAA	
	USAF	USAFR	ANG	USAF	ANG
Total mission personnel	720	856	671	554	625
Full-time personnel	720	300	227	554	239

cost factors. We used the AFPCH model, which resembles the general model described in Sec. II, as the basis for generating the cost estimates for comparable Army active, reserve, and national guard units, with slight modifications to accommodate the special characteristics of ARF units and the overall objectives of the analysis.<sup>5</sup>

First, we modified the AFPCH model to include the "other" training cost element for ARF personnel. This same cost element was included in the Air Force analysis and accounts for additional drill days for special unit or personnel training functions, such as refresher/proficiency training and career development.

Second, we excluded equipment procurement costs and other one-time, nonrecurring costs, so that the resulting Army cost structure and methodology conformed to the general guidelines in Sec. II. Finally, we developed reserve and guard personnel and equipment cost factors on a basis similar to the active factors.

At the time of this study, the Army was respecifying the AFPCH models to update factors and include reserve unit costs. Any future work in the Army unit cost area should consider these new AFPCH models. We note that the new models are based on a costing methodology different from our own; thus, the resulting unit costs may not be similar to those presented here, especially for equipment operations and base support.

### Personnel Categories

Officer, enlisted, and civilian personnel levels are identified for each active and ARF unit. Furthermore, the full-time members (AGRs and ATs) are included for the ARF units. Because aviation units were not examined, there are no rated/nonrated personnel distinctions.

Only the unit personnel requirements identified in the table of organization and equipment (TO&E) are included in the case studies. No additional personnel are directly included for base support functions. Unlike Air Force units, Army battalions have personnel authorized for support functions, such as food services, utilities, and personnel support activities. Therefore, the unit manpower strength includes some variable base-operating-support functions. Furthermore, the per capita factor for other personnel costs includes a pro rata share of the cost of civilian personnel in the base-operating-support budget category.

The unit personnel include only organizational-level maintenance. The cost of personnel in higher-level maintenance activities (both

<sup>5</sup>The Army Reserve Forces (ARF) consist of the United States Army Reserve (USAR) and the Army National Guard (ARNG).

direct support and general support) is included in the operating cost of the equipment wherever possible.

#### Data Sources

A TO&E sets the number of officers and enlisted personnel in the various units. The personnel levels are the same across the three components of the Army for a given type of unit; that is, the active, reserve, and guard units are governed by a common TO&E. We obtained the number of full-time AGR and AT personnel in USAR units from the Department of the Chief of the Army Reserve (DAAR) and the National Guard Bureau (NGB).

A unit TO&E specifies manpower and equipment authorizations for different authorized levels of organization (ALO). The ALOs define the degree of unit readiness, with ALO 1 representing units that will deploy first in a war. Most ALO 1 combat units are in the active force, but few are in CONUS. National Guard roundout brigades are also at ALO 1.<sup>6</sup> Many reserve units and almost all combat support units are staffed at ALO 2 and ALO 3. Costs were estimated for the case study units at both ALO 1 and ALO 2.

The various personnel pay and allowance factors were derived from the FY-1984 Personnel Budget Justifications [8-10], which also provided the "other training" per capita cost factors for reserve force personnel. The FY-1984 Operations and Maintenance Budget Justifications [11-13] provided data to derive the BOS nonpay factors for active and reserve force personnel and the civilian cost factors.

Training cost factors developed for officers and enlisted personnel included pay and allowances during basic and military occupational specialty (MOS) training (MPA [military personnel appropriation]), operations and maintenance of training facilities in support of trainees (OMA [operations and maintenance appropriation]), and ammunition used during training (AMMO). The costs are assumed to be equal for training active, reserve, and guard personnel.

The AFPCH model estimates the MPA, OMA, and AMMO training costs of a unit by multiplying the number of personnel with each MOS by the appropriate costs from the *MOS Cost Handbook* and Training and Doctrine Command (TRADOC) inputs that display the training cost per student for each MOS code or course. Using the estimating formulas in Ref. 24 for recurring and nonrecurring training costs and the resulting training costs for the case study units, we derived the

<sup>6</sup>Roundout brigades consist of reserve force units that drill and train with the active brigades of the combat division. The combat division includes two or three active brigades and one National Guard brigade.

average cost per officer and per enlisted personnel. Separate factors were developed for MPA, OMA, and AMMO.

No available data sources provide reasonable operating costs or peacetime usage for the equipment associated with an Army unit. No programmed factors for Army equipment (except aircraft) specify the number of miles or hours that equipment should be operated in peacetime. The training intensity of units varies by ALO level, budget constraints, and command decisions. Unit-to-unit and even year-to-year expenditures for peacetime training vary widely.

Because of the difficulty in deriving separate operating usage and cost factors that could be used to generate the total equipment operating cost for a unit, we collected site-specific cost data for various active units at Fort Hood and Fort Stewart and from the Texas and Georgia National Guard. The Georgia National Guard contains a roundout brigade attached to the division at Fort Stewart. The Georgia National Guard and the active Fort Stewart units are at ALO 1. The Texas National Guard and the Fort Hood active units are at ALO 2.

Equipment cost estimates were further complicated by the difficulty in associating centralized maintenance costs with individual units. The direct support and general support shops service many units and often do not, or cannot, track their part and labor costs to specific combat units.

The problems with estimating equipment operating costs for similar units in the active and ARF components must be considered when reviewing the case study results. These equipment data cover relatively few units, embody several assumptions, and refer to a specific year of operations. They may not represent typical costs and should be considered as initial, rough estimates. New AFPCH models being developed at the time of this study may provide non-site specific unit equipment operating costs. Future efforts in this area will improve the ability to track and collect equipment cost data. However, as will be seen with the overall unit cost results, personnel-related costs heavily outweigh unit equipment costs. Therefore, despite the variability in the equipment cost estimates, the total unit cost results should not be very sensitive to equipment cost errors.

### Results

The detailed cost estimates for the ALO 2 mechanized infantry and armor battalions are shown in Tables 4 and 5, respectively. Summary-level cost ratios are shown for all the case study units in Table 6.

Table 4  
ARMY OPERATING AND SUPPORT COSTS: MECHANIZED  
INFANTRY BATTALION, ALO 2  
(\$ FY 1983 million)

	USA	ARNG	Ratio <sup>a</sup>
<b>Personnel</b>			
Pay and allowances			
Officer	1.39	0.28	
Enlisted	10.37	1.89	
Total	11.76	2.17	0.18
Other personnel costs			
Officer	0.33	0.02	
Enlisted	4.41	0.31	
Total	4.74	0.32	0.07
Replacement training costs			
Officer	0.07	0.06	
Enlisted	1.68	1.22	
Total	1.75	1.28	0.73
Total personnel costs	18.25	3.78	0.21
<b>Equipment</b>			
Fuel	0.06	0.04	
Training ammunition	0.97	0.21	
Repair parts	0.66	0.20	
Other	0.19	0.05	
Total equipment costs	1.88	0.50	0.27
<b>Total unit costs</b>	<b>20.13</b>	<b>4.27</b>	<b>0.21</b>

<sup>a</sup>National Guard cost divided by active cost.

The ratio of guard to active total unit O&S cost is comparable across the four case studies and the two ALOs—the guard unit's cost is 20 percent to 30 percent of the active unit's cost. The slightly higher ratios for the Georgia units most likely reflect the higher priority of the National Guard roundout units. The roundout battalions have a more complete complement of equipment and personnel than the Texas units, and their ALO 1 status requires a higher level of readiness. The Georgia units, therefore, have a larger share of the budget dollars and

exercise their equipment more frequently than the Texas National Guard units.<sup>7</sup>

Tables 4 and 5 show that personnel costs dominate a unit's annual operating and support costs. Personnel-related expenditures are 75 percent to 90 percent of the total O&S costs for the active units and 65 percent to 90 percent of the total for the National Guard units. The resulting guard-to-active-personnel-cost ratio of approximately 25

**Table 5**  
**ARMY OPERATING AND SUPPORT COSTS: TANK**  
**BATTALION, ALO 2**  
(\$ FY 1983 million)

	USA	ARNG	Ratio <sup>a</sup>
<b>Personnel</b>			
Pay and allowances			
Officer	1.16	0.24	
Enlisted	7.05	1.34	
Total	8.21	1.58	0.19
Other personnel costs			
Officer	0.28	0.02	
Enlisted	3.00	0.21	
Total	3.28	0.23	0.07
Replacement training costs			
Officer	0.10	0.06	
Enlisted	1.62	1.19	
Total	1.72	1.25	0.73
Total personnel costs	13.21	3.06	0.23
<b>Equipment</b>			
Fuel	0.14	0.04	
Training ammunition	1.62	0.38	
Repair parts	1.19	0.23	
Other	0.18	0.04	
Total equipment costs	3.13	0.69	0.22
Total unit costs	16.33	3.75	0.23

<sup>a</sup>National Guard cost divided by active cost.

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<sup>7</sup>The Georgia National Guard units were undergoing equipment modernization and preparing for a tour at the National Training Center during the period represented by the equipment operating costs. The resulting costs may therefore be higher than those in a more normal period.

percent drives the ratio of total unit costs. The 25 percent factor reflects the part-time nature of ARF operations in peacetime and the relatively few full-time personnel (either ATs or AGRs) associated with ARF units.

The ratio of equipment costs shows different patterns in the Georgia and Texas cases. For Texas, the guard-to-active-equipment-operating-cost ratio is fairly uniform across the three case study units and approximately equals the personnel cost ratios. For the Georgia units, however, the equipment ratios vary widely across the different types of units and appear significantly larger than the personnel-cost ratios. The higher priority and readiness levels of the Georgia roundout units undoubtedly contribute to the Georgia guard's higher equipment operating costs.

Because of the uncertainty in the equipment operating costs, an upper bound on the ratio of guard to active annual unit O&S costs may be estimated by assuming that the guard and active forces have equal equipment operating costs. This assumption implies equal peacetime training operations for active and guard units and, therefore, a much more intense training tempo for the guard units because of their part-time status. The assumption of equal equipment costs affects the ratio of total O&S costs relatively little—at most adding 10 percentage points. This implies that the uncertainty of the proper estimate for equipment operating cost is overshadowed by the large unit personnel

Table 6  
RATIO OF ARMY NATIONAL GUARD TO USA COSTS

	Infantry	Tank	Field Artillery	Engineer
<b>Personnel</b>				
Georgia (ALO 1)	.20	.23	.23	.21
Texas (ALO 2)	.21	.23	.23	--
<b>Equipment</b>				
Georgia (ALO 1)	.58	.47	.68	1.23
Texas (ALO 2)	.27	.22	.23	--
<b>Total</b>				
Georgia (ALO 1)	.24	.28	.30	.26
Texas (ALO 2)	.21	.23	.23	--

costs and that the resulting unit-cost ratios are relatively insensitive to any errors in estimating equipment costs.

The results of the four case studies suggest that ARF units cost significantly less than comparable active units on an annual recurring basis with the resulting ARF-to-active ratios in the 25 percent range.

## NAVY

Unlike the Air Force and the Army, the Navy has not developed a model for estimating the annual O&S costs of its units. For the Navy case studies, therefore, we applied the cost categories used for the analysis of Air Force and Army units, modified to fit the unique costs of Navy aviation squadrons and ships. The *Navy Program Factors Manual* [25] and the Visibility and Management of Operating and Support Costs (VAMOSC) data collection system provided additional data that helped us to formulate the cost structure for the Navy unit cost analysis.

### Personnel Categories

The unit personnel are divided into full-time and part-time officers and enlisted and include the equipment operators, organizational-level maintenance personnel, and unit administrative and overhead personnel. Aircraft squadron personnel requirements also include the variable support personnel (supply, laundry, food services, etc.) required to augment the aircraft carrier or shore station support functions, plus a complement of intermediate maintenance personnel on temporary assigned duty (TAD) to the centralized carrier or shore station Aircraft Intermediate Maintenance Department (AIMD). Ship personnel requirements also include variable support personnel; however, they do not include intermediate-level maintenance personnel.

The personnel in aviation units are segregated into flight-rated, or aircrew, personnel and non-flight-rated, or ground, personnel. Within the aircrew category, pilots and other officer aircrew members (the naval flight officers in the F-4S squadron) are further differentiated because of the additional flight pay for aircrew members and the high training cost of pilots and other aircrew personnel. For ship units, a pay factor is also included for additional sea pay.

Active and reserve units, whether ships or aircraft squadrons, have both full-time and part-time members. For the active units, the full-time military complement represents the personnel needed for normal peacetime operations. Because additional personnel are needed in

wartime, each active unit will be augmented by designated selected reserves at the time of mobilization. These reserve augmentees usually train with their active unit (or a comparable active unit) during at least part of their active duty training periods.

Navy reserve units require a large complement of full-time personnel to provide the continuing equipment maintenance and administrative support needed for peacetime operations. The full-time personnel are either TARs, who are reserve personnel on full-time active duty, or active (USN) personnel assigned to a reserve unit.

Reserve ships have been mandated by the Congress to have no more than 50 percent full-time personnel, with the full-time manning being all TARs. However, most reserve ships currently have slightly more than 50 percent full-time manning and require active USN personnel to fill some of the full-time slots because of shortfalls in certain ratings in the TAR community. The Navy reserve is correcting these rating shortfalls, and eventually reserve ships will use only TARs as the full-time complement. Reserve aircraft squadrons have TARs as their full-time members but usually no active USN personnel.

### Data Sources

The unit personnel requirements, including the number of full-time and part-time officers and enlisted, are identified in the appropriate Manpower Authorization Form (1000/2). Each unit in the active and reserve Navy has a unique 1000/2 document that specifies unit personnel requirements. Across all units of a given type—for example, FF1052-class frigates—the total number of personnel will vary slightly, depending on the specific equipment on a given ship.

We developed most per capita factors from data contained in the Budget Justifications [14–17] or information received from various personnel offices in the active and reserve organizations. Training costs per student were extracted from Ref. 26; data on aircrew training came from the Aviation Manpower and Training Division, Deputy Chief of Naval Operations (DCNO) for Air Warfare (OP-59). Personnel turnover factors were developed from the personnel losses shown in the Budget Justifications, tempered by prior-service gains for the reserve force, and, for aircrew, from the output of the aircrew training pipelines.

Peacetime programmed operating levels for equipment were obtained from the Program Planning Office (OP0921 for active and OP09R3 for reserve) for the FF1052-class frigates and from the Deputy Chief of Naval Operations (DCNO) for Air Warfare (OP-51) for the F-4S aircraft. The fixed and variable cost factors for the different categories of

equipment were developed primarily from data in the VAMOSC ship and air historical data reports and from various organizations in the active and reserve headquarters. Separate cost factors were developed for active and reserve equipment whenever possible. If component-unique data were not available, we assumed the cost factors to be equal for active and reserve equipment.

### Results

The annual O&S cost estimates for active and reserve FF1052-class frigates are displayed in Table 7; the results for the F-4S aviation squadrons are shown in Table 8. The active and reserve units show slightly different results: The reserve FF1052 ships have an annual cost of approximately 86 percent of their active counterparts, while the reserve F-4S units have a cost of approximately 54 percent of the active squadrons.

The reserve/active cost ratios differ for the ships and aircraft for several reasons. First, the reserve ships have a higher percentage of full-time manning (either active USN or TAR) than the reserve F-4S squadrons. Almost 54 percent of the reserve FF1052 ship's company is full-time, but only 38 percent of the reserve F-4S squadron's personnel are full-time. The higher number of full-time people directly affects the personnel-related costs of the unit: The reserve FF1052's personnel-related costs are approximately two-thirds those of the active ship, while the personnel-related costs for the reserve F-4S squadron are only one-third those of the active squadron.

Reserve/active cost ratios also differ for ships and aircraft because of the comparable reserve/active equipment operating cost. For the FF1052 ships, the reserve unit has higher annual equipment operating cost than the active unit, primarily because a reserve ship has intermediate-level maintenance cost five times that of an active ship. The high intermediate-level cost results from the high portion of organizational-level maintenance that is performed at the intermediate level on reserve ships. On active ships, the full-time personnel complement can handle all required organizational-level maintenance. The reduced full-time manning of the reserve FF1052s, however, cannot handle all organizational-level repairs, and intermediate-level maintenance thus has to perform some organizational-level work.

In the F-4S units, the lower equipment operating cost for the reserve stems from the curtailed flying program (approximately 73 percent of the active peacetime flying program) and from the lower cost per flying hour for reserve units. Reserve unit costs are also lower because of the significantly lower replacement training cost of reserve units. For

**Table 7**  
**NAVY UNIT OPERATING AND SUPPORT COSTS,**  
**FF1052 FRIGATE**  
**(\$ FY 1983 million)**

	USN	USNR	Ratio <sup>a</sup>
<b>Personnel</b>			
Pay and allowances			
Officer--part-time	0	0.06	
Officer--full-time	0.64	0.36	
Enlisted--part-time	0.10	0.45	
Enlisted--full-time	4.59	2.81	
Total	5.34	3.69	0.69
Other personnel costs			
Officer	0.12	0.07	
Enlisted	1.55	0.89	
Total	1.67	0.96	0.57
Replacement training costs			
Pilot	0	0	
Other rated officer	0	0	
Nonrated officer	0.11	0.08	
Enlisted	0.96	0.38	
Other reserve training	0	0.01	
Total	1.07	0.47	0.44
Total personnel costs	8.08	5.12	0.63
<b>Equipment</b>			
POL	2.53	1.09	
Utilities	0.28	0.42	
Supplies	0.27	0.18	
Repair parts	0.66	0.66	
Intermediate maintenance	0.46	2.39	
Overhaul	4.77	4.77	
Ordnance	0.41	0.41	
Total equipment costs	9.38	9.93	1.06
Total unit costs	17.46	15.05	0.86

NOTE: Sums may not add because of rounding.

<sup>a</sup>Reserve cost divided by active cost.

5. /

**Table 8**  
**NAVY UNIT OPERATING AND SUPPORT COSTS**  
**F-4S SQUADRON, PAA 12**  
(\$ FY 1983 million)

	USN	USNR	Ratio <sup>a</sup>
<b>Personnel</b>			
Pay and allowances			
Officer--part-time	0.06	0.41	
Officer--full-time	1.27	0.22	
Enlisted--part-time	0.01	0.37	
Enlisted--full-time	4.09	1.77	
Total	5.43	2.77	0.51
Other personnel costs			
Officer	0.23	0.09	
Enlisted	1.33	0.52	
Total	1.56	0.61	0.39
Replacement training costs			
Pilot	2.53	0	
Other rated officer	0.85	0	
Nonrated officer	0.02	0.01	
Enlisted	0.82	0.13	
Other reserve training costs	0.01	0.02	
Total	4.23	0.16	0.04
Total personnel costs	11.23	3.54	0.32
<b>Equipment</b>			
POL	5.92	3.57	
Maintenance supplies	2.79	1.45	
Replenishment spares	0.18	0.13	
Depot maintenance	4.02	3.36	
Modifications	2.22	2.22	
Ordnance	1.25	0.50	
Total equipment costs	16.38	11.24	0.69
Total unit costs	27.61	14.78	.54

<sup>a</sup>Reserve cost divided by active cost.

aviation units, the replacement training cost is driven by the large cost of training pilots and other aircrew members. Since all reserve aircrew have previously served in the active force, reserve aviation units do not experience the high cost of training replacement aircrew members.

Overall, the reserve ships have only a small cost advantage over the active FF1052s. As mentioned, this is due to the high percentage of full-time manning required in peacetime and to the high fixed

operating cost. The reserve F-4S units, however, show significant cost savings over their active counterparts, thanks primarily to the low percentage of full-time manning and to the lower equipment operating costs.

### MILITARY RETIREMENT COST ESTIMATES

The case study cost estimates displayed in Tables 1-8, above, include no costs for military retirement. As one estimate of the additional unit personnel cost for future military retirement benefits, we added an aggregate factor of 50.7 percent of base pay to the original cost estimates. This factor represents the current Normal Cost Percentage developed by the DoD Office of the Actuary and included in the FY-1985 Personnel Budget Justifications.

A second case was based on the dual accrual percentages of 8.1 percent for the reserve and 52.2 percent for the active. The DoD Actuary also developed these dual accrual percentages, using the same models on which the single accrual NCP was based. The resulting ratios of reserve force to active unit operating and support costs for a number of the case study units are displayed in Table 9. The other case study units showed similarly changed ratios of reserve to active unit costs to those displayed in Table 9.

The results in Table 9 suggest that the ratio of reserve to active unit cost changes very little when retirement costs based on the single accrual percentage are added. The largest percent decrease in the ratio occurs for the Air Force and Army units because personnel costs are such a large portion of total unit costs. The Case 2 results reflect the

Table 9  
RATIO OF RESERVE TO ACTIVE COSTS  
WITH AND WITHOUT RETIREMENT

	C-130E (16 PAA)	Infantry (ALO 2)	FF1052 Frigate
Base case: no retirement	.72	.21	.86
Case 1: single accrual	.67	.21	.85
Case 2: dual accrual	.65	.18	.82

logical extension of Case 1—if reserve personnel have a lower accrual than active personnel, the cost ratios will be further reduced. For Case 2, the ratio of reserve to active unit cost including retirement is 85 percent to 95 percent of the ratio without retirement.

The results suggest that, based on the single and dual accrual assumptions embedded in DoD Actuary's models, including military retirement cost increases the cost advantage of the reserve force units analyzed. The magnitude of the cost differential increase between the annual costs of active and reserve force units depends largely on the many assumptions and factors used to estimate the future cost of military retirement.

The individual case studies provide information on the costs of comparable active and reserve units in each of the military services. The conclusions that follow look across these results to reveal the factors that drive active and reserve unit costs and the differences between the components that result in savings in the annual O&S costs of reserve force units.

## **IV. GENERAL ANALYSIS AND FUTURE COST RESEARCH**

The unit O&S cost-estimating models provide previously lacking analytic techniques for the economic analysis required in force mix decisions. The case study analyses also indicate the factors that affect annual unit costs and contribute to the cost differences between active and reserve units. This section presents our conclusions regarding the cost analysis of active and reserve force units.

Because personnel and equipment cost factors are a necessary input to the economic analysis of military units, we first describe the availability and quality of the existing data and identify those areas where data improvements would strengthen future cost analysis and aid policy decisions on the cost aspects of the force mix. We then use the case study results to describe the types of units that would reduce the annual O&S costs if the units were placed in the reserve force. Finally, we propose future research topics that would yield further insight into the comparable cost of active and reserve force units and provide the additional economic analysis required for force mix decisions.

### **DATA AVAILABILITY**

The quality and availability of the data needed to formulate the cost estimates for the active and reserve force units varied widely across services and components. In many areas, suitable personnel and equipment factors were readily available or could be developed from published sources. In other cases, existing cost collection and reporting systems did not track the types of data required for the cost analysis. Figure 1 compares data availability in the various factor categories for the three services.

In general, the data needed to develop the *personnel levels* are available for each service component. Each service has a document that lists the authorized military personnel levels for a unit. These documents may refer to notional units (such as the Army TO&Es) or to specific units (such as the Air Force UMDs and the Navy 1000/2s). In addition, the reserve components can supply the numbers and types of full-time personnel associated with individual units.

Most *per capita cost factors* either are available from service documents or organizations or can be developed from information in the

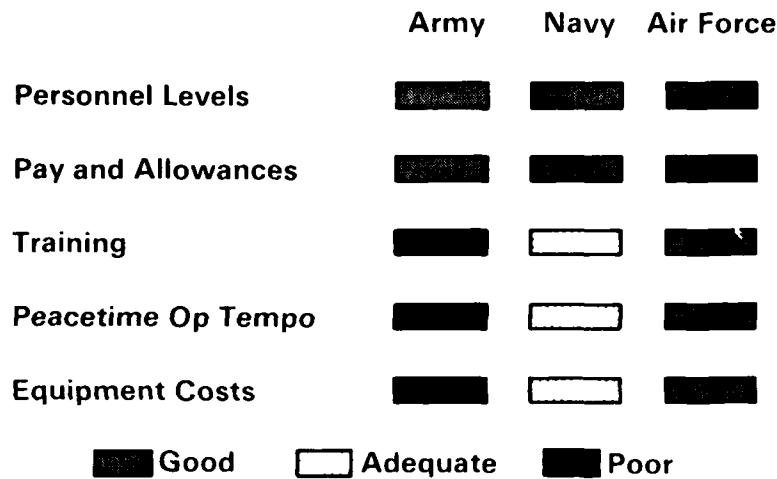


Fig. 1—Data availability

Personnel Budget Justifications and the Operations and Maintenance Budget Justifications. Questions arise in terms of how to apportion costs (such as base operating support costs), but typically, enough information is available to support reasonable estimates of the appropriate cost factors.

The *acquisition and school training costs* of individuals represents an area of personnel cost where the data need improvement. The methods used in the case study analysis to develop these training cost factors varied across the services. For the Air Force, average factors contained in AFR 173-13 [21] were adopted for the C-130 and F-4 analyses. The AFR 173-13 factors for pilot and other aircrew training were augmented with information received from the Tactical Air Command and the Military Airlift Command. The training cost factors for the Army were based on summary information contained in the *Army Force Planning Cost Handbook* [24]. The Navy factors were extracted from a study by the Center for Naval Analyses [26]. Because of the different

sources for training school costs, the results may not be consistent across the three services.

The availability of *equipment operating and cost* data varied greatly among the services. The Air Force has made available peacetime operating levels and published various equipment cost factors [21] for both active and reserve force aircraft. The Navy keeps data on operating factors, but we had to infer the cost factors from the VAMOSC cost collection system. The Army has little or no data on the peacetime operating levels of unit equipment or the various elements of operating cost. Therefore, we based the Army equipment-related cost estimates on site-specific data collection. The Army equipment cost problems are caused by the wide range of equipment associated with Army units and the variability in operations across units and over time.

Fortunately, the lack of adequate data for training school costs and Army equipment operations only slightly affected the resulting unit cost estimates. Replacement training costs are typically lower than other elements of personnel cost. The more expensive aircrew training costs are tracked more closely by the services, and the factors used in the case study analyses should be good estimates of the cost to train pilots and other crew members. Moreover, the personnel-related costs of Army units greatly outweigh equipment operating costs. Errors in estimating Army unit equipment costs do not adversely affect the unit cost estimates.

The services recognize the shortcomings of the available data used for unit cost analysis. The Navy is continually working to strengthen the VAMOSC systems for aircraft and ships. The Army recently began to overhaul and update the Force Cost Information System that serves as the basis for the AFPCH. These initiatives should correct the data deficiencies and result in the publication of cost factors for each service and component. Better data will improve the cost analysis of active and reserve force units and provide a firmer foundation for the cost inputs needed for force mix decisions.

### CASE STUDY IMPLICATIONS

Based on the case study analyses, we noted the following differences in annual O&S costs for similar active and reserve force units: The smaller the portion of active unit cost that is attributable to equipment operations and maintenance (including unit maintenance personnel), the greater the relative cost saving of placing the unit in the reserve force. Stated in another way, the larger the portion of unit cost for

combat-oriented personnel, the greater the cost saving of placing the unit in the reserve force. Therefore, for labor-intensive units, such as those in the Army case studies, the ratio of reserve to active cost is relatively low, in the 20 percent to 30 percent range. For the capital-intensive aviation and ship units, the ratio is much higher, in the 70 percent to 90 percent range. Of course, these cost comparisons are subject to the proviso that the relative military capabilities of the units may not be the same and cannot be assumed to be equal.

### **Unit Personnel Costs**

Conventional wisdom suggests that the personnel cost of reserve units should be approximately 20 percent of the personnel cost of a similar active unit, based on the premise that reservists serve about 20 percent of the year in peacetime. Our case study analyses refute this premise, indicating that the personnel cost of reserve units can significantly exceed 20 percent. For the aviation and ship units, reserve unit personnel costs ranged from 32 percent to 80 percent of the personnel cost of the comparable active unit.

The unexpectedly large personnel cost is attributable to the full-time members of the reserve units. These full-time unit personnel provide the continuous level of equipment maintenance and unit support needed in peacetime. Although most part-time reservists drill only on weekends (excluding the two-week active duty training each year), many reserve unit activities continue during the week. For example, Air Force and Navy pilots often train on weekdays, and full-time personnel must maintain and prepare the aircraft for these flights.

Because of the relationship between full-time maintenance personnel requirements and equipment activity levels, changing the level of operations in peacetime will affect more than just equipment operation cost. An increase in the programmed flying hours for reserve aviation units will increase the cost of POL, spare parts, and other variable elements of operating costs. More flying hours may also require more full-time maintenance support, thus increasing the personnel-related cost of reserve units. An example of this effect occurs in Air Force air defense and strategic tanker units, where the cost of reserve and active units is similar.

### **Unit Equipment Operating Cost**

Most reserve force units operate their equipment less frequently in peacetime than does a comparable active unit. The lower equipment

operating tempo reduces the variable portion of equipment-related costs; as a result, reserve units usually have lower annual equipment costs than their active counterparts. The effect of lower equipment operations on total annual costs differs for aviation and ship units.

Table 10 shows the active and reserve peacetime operating levels and the fixed and variable portions of equipment-related cost for C-130E units in the Air Force, F-4S Navy aircraft units, and FF1052 ships. For the aviation units, the variable part of equipment cost is significantly larger than the fixed portion. Therefore, a change in the peacetime operating level of these units will result in a comparable change in the ratio of reserve unit to active unit equipment cost. For example, the current ratio of reserve to active C-130E equipment-related cost is about 70 percent. If the flying hours of the reserve unit were increased by 20 percent (from 462 to 554), the ratio of reserve to active equipment cost would increase to almost 80 percent. Thus, we note a significant correlation between unit cost and the operating levels of the aviation unit.

The FF1052-class ships show a different ratio of fixed to variable equipment-related cost. For these ships, the fixed portion of equipment cost far outweighs the variable portion due to steaming the ship. Therefore, the annual steaming hours could be dramatically increased and the ratio of reserve to active equipment cost would

Table 10  
ANNUAL UNIT EQUIPMENT OPERATING COSTS  
(\$ FY 1983 million)

	C-130E (16 PAA)		FF1052		F-4S (12 PAA)	
	USAF	ANG	USN	USNR	USN	USNR
Peacetime operating level (flight hrs/aircraft/yr or steaming hrs/ship/yr)	720	462	3022	1116	302	219
Equipment costs						
Fixed	3.08	3.08	6.57	8.41	5.09	4.35
Variable	14.96	9.32	2.81	1.52	11.29	6.90
Total	18.04	12.40	9.38	9.93	16.38	11.24

change little. For this class of ships, the lower steaming requirement of the reserve has little effect on total unit cost, resulting in a relatively high ratio of reserve unit to active unit cost (approximately 85 percent for the FF1052 ships).

Equipment-related costs constitute a large part of the total annual O&S costs for ship and aviation units. Alternative reserve force peacetime training strategies aimed at reducing equipment-related costs could substantially affect the cost differences between active and reserve units. Because the case study results show different ratios of variable to fixed costs, new training procedures might differ for ship units and aviation units.

#### OTHER ISSUES

The case study results reflect the average annual costs of active and reserve force units in the current force. The marginal cost of adding an additional unit to the current force mix may differ from the average costs shown in the case study results.

The reserve force benefits from the ability to recruit personnel with prior military service. These personnel, having trained in the active force, reduce the replacement training costs of reserve force units. If economic conditions increase active personnel retention or force mix decisions draw down the pool of potential prior-service inductees into the reserve, reserve force training costs will increase. These additional training costs may be very high; for example, the training of an aircraft pilot costs approximately \$1 million. For certain elements of annual cost, an additional reserve force unit may experience higher marginal costs than the case study estimates.

The marginal costs of augmenting the reserve force may also decrease. One example involves the peacetime base support costs for Air National Guard units. Many ANG units are currently based on commercial airfields, resulting in relatively high BOS costs. Adding another unit to such a base may only slightly increase the total base operating support costs. Another, potentially less costly, form of reserve augmentation would add more equipment to an existing reserve unit. Again in the Air Force cases, many reserve units are assigned fewer aircraft than similar active units. For example, many USAFR C-130 units have eight aircraft, while most active units have sixteen. Augmenting an existing unit would take advantage of economies of scale in certain personnel and support cost areas.

The case study results show that Army units have the lowest ratios of reserve to active cost. Although these ratios are much lower for

Army units than for Air Force or Navy units, the absolute cost difference may be similar. For example, a reserve infantry battalion has an annual cost of 21 percent of an active infantry battalion, with an absolute dollar difference of approximately \$15.86 million. The Air Force National Guard F-4D unit has an annual cost of 71 percent of the active unit, but the dollar difference is approximately \$13.58 million. Therefore, the ratio of reserve to active cost should not be the only metric used to compare units; the dollar difference better represents budget implications.

The lower annual costs of reserve units indicated by the case study results may not apply to all types of units. Reserve units in peacetime are typically less expensive than active units because they operate their equipment less and serve only part-time. If the peacetime mission of the reserve unit, rather than the training required for wartime, drives the equipment operating tempo, reserve units will have the same (or greater) equipment operating levels as the active force. Higher reserve equipment operations increase both equipment-related costs and personnel costs, since more full-time personnel, and possibly more part-time reservists, are required to support the peacetime operations. The general cost analysis of active and reserve force units must consider the cost effects of the peacetime missions in addition to the results of the case studies presented here.

A final remark deals with comparing unit costs across the three services. Each service has different policies regarding manpower requirements and personnel responsibilities, the recruiting of prior-service personnel, the maintenance policy for equipment support, and the basing of units in peacetime. These differences, along with the problems encountered in each service in estimating unit costs, must be considered when comparing like units in different services. For example, one should not compare the cost of F-4 units in the Air Force with the cost of F-4 units in the Navy solely on the basis of the models and factors described in this report.

#### COST AREAS FOR FUTURE RESEARCH

The individual case study results and the general observations on unit personnel and equipment operating costs illuminate the cost aspects of deciding the total force mix of active and reserve units. Costs are certainly not the only criterion in force mix decisions. Other attributes, such as capability, force size constraints, and required rotation bases must also enter into the final determination of which and how many units should be placed in the various components of the

force. Although the unit O&S cost models and accompanying data bases provide the necessary tools to estimate the major cost implications of force mix decisions, further research in active and reserve costs would strengthen the overall policy analysis.

Future cost research should be devoted to understanding the nonrecurring transition costs (activation and deactivation) and to determining the difference between average and marginal costs for selected categories of units. Activation costs include such elements as new construction and modification of existing facilities, the transportation of personnel and equipment, and the acquisition and initial training of unit personnel. The magnitude of these nonrecurring cost elements may vary greatly, depending on the type of unit and the specific basing location. Further analysis should attempt to enumerate and quantify the one-time transition costs and to describe the specific characteristics and situations that affect activation and deactivation cost.

Changes in the mix of active and reserve component units can affect the marginal costs of personnel. As the pool of individuals with prior service expands or shrinks, the reserve force will experience lower or higher personnel acquisition and training costs. Analysis should be directed at understanding the availability of both prior-service and non-prior-service personnel in various skill groupings and in various locations. The effect of different force mixes on average personnel costs also should be quantified.

Finally, different unit and personnel training strategies for the reserve force, including the greater use of simulators and closer integration with active units (such as Army roundout divisions and Air Force associate squadrons), should be analyzed from both a training effectiveness and cost perspective.

Complete analysis of the active/reserve balance requires evaluation of the effects of changes on military capabilities. This, in turn, requires the ability to cost out changes in training strategies, maintenance policies, and peacetime operating tempos, all intended to maintain capabilities in the presence of changes in the active/reserve balance.

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## **Appendix A**

### **AIR FORCE COST FACTOR DERIVATION**

The development of cost factors for the Air Force active (USAF), reserve (USAFR), and guard (ANG) units, including the appropriate data sources, is described in this appendix. The factors are specifically developed for C-130E and F-4D squadrons. The C-130E squadrons have either 8 or 16 authorized aircraft. The F-4D squadrons have either 18 or 24 authorized aircraft.

This appendix shows the derivation of personnel and equipment cost factors, the necessary cost-estimating equations, and the Air Force case study results. All costs are given in FY 1983 dollars unless otherwise specified. References and a glossary appear at the end of Appendix A.

#### **PERSONNEL COST FACTOR SUMMARY**

The personnel cost factors are summarized in Tables A.1 and A.2. The derivation of these cost factors is described in the following sections.

#### **PERSONNEL STRENGTH**

##### **Unit Personnel**

The unit personnel strength factors include crew ratios, crew composition, and required personnel levels. Crew ratios and compositions are used to determine the number of rated officers and enlisted personnel in a squadron. Crew ratios and the number of supervisory flight crew personnel assigned to a squadron are from Ref. A.1, Table 4-4, for the active forces; Table 4-5, for the guard forces; and Table 4-6, for the reserve forces. Unit mission personnel requirements for the model are from Ref. A.1, Table 4-7, for the active squadrons and from Ref. A.2 for the reserve and guard units; averages for all CONUS F-4D and C-130E units were used.

Mission personnel were identified by functional account code as either aircrew, wing and group staffs, aircraft maintenance, or weapon system security. Personnel were further identified as officer, enlisted,

**Table A.1**  
**AIR FORCE PERSONNEL COST FACTOR SUMMARY**

Cost Factors	USAF		USAFR		ANG	
	Rated	Non-rated	Rated	Non-rated	Rated	Non-rated
<b>Pay and allowances</b>						
Officer						
Full-time active and AGR	38,435	34,860	51,775	51,775	42,227	42,227
Part-time reserve	--	--	8,124	4,979	8,796	5,531
Enlisted						
Full-time active and AGR	17,194	15,873	27,661	27,661	20,621	20,621
Part-time reserve	--	--	3,791	2,418	4,645	2,645
Civilian						
TAC	--	25,351	--	25,927	--	28,725
MAC	--	25,583	--	25,927	--	28,725
<b>Other personnel costs</b>						
Officer						
Full-time active and AGR	4,331	4,331	1,692	1,692	2,385	2,385
Part-time reserve	--	--	912	912	1,768	1,768
Enlisted						
Full-time active and AGR	3,466	3,466	1,895	1,895	1,759	1,759
Part-time reserve	--	--	858	858	1,669	1,669
Civilian						
Non-AT/ART	5,833	5,833	922	922	2,070	2,070
AT/ART	0	0	384	384	529	529
<b>Other reserve training</b>						
Part-time officer	0	0	1,867	1,867	2,829	2,829
Part-time enlisted	0	0	610	610	278	278

NOTES: AGR = active guard/reserve (full-time). Owing to data constraints, AGRs are not broken down by rated and nonrated. AT = air technician (guard); ART = air reserve technician.

full-time technician (part-time reservist but full-time civilian), and civilian. The units under study had neither activated nor full-time reservists (AGRs).

The crew ratio times the number of aircraft in a squadron yields the number of crews. Applying the number and type of personnel per crew results in the total officer and enlisted aircrew members. For the cases examined, the crew ratios were the same for the active, USAFR, and ANG units.

**Table A.2**  
**AIR FORCE REPLACEMENT ACQUISITION AND**  
**TRAINING COST FACTOR SUMMARY**  
**(\$ FY 1983 per capita)**

	USAF	USAFR	ANG
<b>F-4D</b>			
Officer			
Pilot	108,404	24,685	43,968
Other aircrew	64,412	20,383	52,240
Nonflight	4,060	1,164	660
Enlisted			
Aircrew	--	--	--
Nonflight	1,659	915	627
<b>C-130E</b>			
Officer			
Pilot	65,509	14,614	26,064
Other aircrew	27,488	8,075	20,746
Nonflight	4,060	1,164	660
Enlisted			
Aircrew	10,096	1,386	1,391
Nonflight	1,659	915	627

NOTE: The numbers represent (training cost/  
student) \* (training turnover) + (\$ acquisition  
cost/student) \* (acquisition turnover).

The manning strengths for the reserve flying units include an appropriate share of the number of personnel on the wing and group headquarters staffs. That is, the typical squadron (representing a three-squadron reserve wing command with one wing headquarters and two group headquarters) will include in its strength estimate a one-third share of the total manning of the wing headquarters and two group headquarters staffs. The unit personnel strengths for the two F-4D cases are shown in Table A.3. The factors for the C-130E are given in Table A.4.

#### **Support Personnel**

Support personnel include the number of officer, enlisted, and civilian personnel in the base operating support,<sup>1</sup> real property mainte-

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<sup>1</sup>Non-personnel-related base operating support costs are included as per capita factors under Other Personnel Costs, below.

**Table A.3**  
**AIR FORCE F-4D UNIT PERSONNEL STRENGTH**

	PAA 24			PAA 18		
	USAF	USAFR	ANG	USAF	USAFR	ANG
Crew ratio	1.25	1.25	1.25	1.25	1.25	1.25
Pilot/crew	1	1	1	1	1	1
Other officer/crew	1	1	1	1	1	1
Enlisted/crew	0	0	0	0	0	0
Personnel strength						
Flying squadron						
Officer	60	60	60	45	45	45
Enlisted	0	0	0	0	0	0
(ART/AT)	(0)	(0)	(0)	(0)	(0)	(0)
(Supervisory)	(7)	(12)	(13)	(6)	(12)	(13)
Civilian	0	0	0	0	0	0
Staff						
Officer	15	38	30	15	38	30
Enlisted	31	47	43	31	47	45
(ART/AT)	(0)	(24)	(27)	(0)	(23)	(29)
Civilian	0	23	0	0	21	0
Maintenance						
Officer	12	9	8	10	9	8
Enlisted	587	620	482	476	548	365
(ART/AT)	(0)	(244)	(200)	(0)	(226)	(176)
Civilian	0	8	0	0	5	0
Weapon system security						
Officer	0	1	1	0	1	1
Enlisted	15	50	47	15	50	47
(ART/AT)	(0)	(1)	(0)	(0)	(1)	(0)
Civilian	0	0	0	0	0	0
Total <sup>a</sup>	720	856	671	592	764	541

<sup>a</sup> ARTs, ATs, and supervisory personnel are included in officer and enlisted strength; the values therefore are not additive. Civilian numbers do not include ARTs or ATs.

nance, and medical support functions for various basing alternatives. The personnel represent an estimate of the incremental support personnel needed when an additional unit moves onto the base.

Figures on active force personnel are from Ref. A.1, Table 4-7. For reserve and guard units, the number of support personnel is based on Ref. A.2. The number of personnel in support functions on a base was

**Table A.4**  
**AIR FORCE C-130E UNIT PERSONNEL STRENGTH**

	PAA 16		PAA 8	
	USAF	ANG	USAFR	ANG
Crew ratio	2.00	2.00	2.00	2.00
Pilot/crew	2	2	2	2
Other officer/crew	1	1	1	1
Enlisted/crew	2	2	2	2
Personnel strength				
<i>Flying squadron</i>				
Officer	96	96	48	48
Enlisted	64	64	32	32
(ART/AT)	(0)	(0)	(13)	(0)
(Supervisory)	(10)	(18)	(12)	(17)
Civilian	0	0	0	0
<i>Staff</i>				
Officer	13	28	26	27
Enlisted	28	46	39	41
(ART/AT)	(0)	(55)	(20)	(30)
Civilian	1	0	27	0
<i>Maintenance</i>				
Officer	6	7	4	4
Enlisted	322	353	171	176
(ART/AT)	(0)	(184)	(94)	(107)
Civilian	4	0	4	0
<i>Weapon system security</i>				
Officer	0	1	1	1
Enlisted	20	30	44	30
(ART/AT)	(0)	(0)	(1)	(0)
Civilian	0	0	0	0
Total <sup>a</sup>	554	625	396	359

<sup>a</sup>ARTs, ATs, and supervisory personnel are included in officer and enlisted personnel strengths; the values are therefore not additive. Civilian numbers do not include ARTs or ATs.

spread on a strength basis to the units located on the base. For example, if a base has 1000 reservists, of whom 200 are in support functions, 600 are in the aircraft unit, and 200 are in other types of units (civil engineers, weather, etc.), then the aircraft unit is allocated 75 percent (600/800) of the 200 support personnel.

For ARF units on active bases, the resulting support personnel should represent the incremental support due to the ARF unit (similar to the support personnel for an active unit). The same applies to units on commercial airfields. The nonincremental portion of personnel, such as air traffic controllers and runway maintenance, is supplied by the local community or owner of the field. The ANG provides only that portion of personnel needed to support the specific unit's aircraft. In both cases, the ARF units provide no portion of the base opening package. For ARF units on ARF airfields, the support personnel may include a share of the base opening package. Data limitations preclude a more accurate breakdown. The support personnel requirements are shown in Table A.5.

Table A.5  
AIR FORCE BASE SUPPORT PERSONNEL STRENGTH

Basing Option	USAF			USAFR			ANG		
	Off	Enl	Civ	Off	Enl	Civ	Off	Enl	Civ
<b>F-4D, PAA 24</b>									
Active	4	96	20	8	80	5	--	--	--
Commercial	--	--	--	--	--	--	15	150	69
<b>F-4D, PAA 18</b>									
Active	3	79	16	7	75	5	11	108	45
Commercial	--	--	--	--	--	--	14	156	63
<b>C-130E, PAA 16</b>									
Active	5	39	24	--	--	--	--	--	--
Commercial	--	--	--	--	--	--	10	116	61
<b>C-130E, PAA 8</b>									
Active	--	--	--	6	66	9	--	--	--
Reserve	--	--	--	15	110	84	7	76	34
Commercial	--	--	--	--	--	--	11	110	50

### PER CAPITA COST FACTORS

Per capita factors include values for military and civilian pay and allowances, acquisition and training, and other support costs. These factors are derived for the most part on an average basis using costs and strengths as shown in the Budget Justifications [A.3-A.8]. Table A.6 shows the strengths used in the calculations.

**Table A.6**  
**AIR FORCE PERSONNEL STRENGTHS**

	Part-Time		Full-Time		
	Officer	Enlisted	Officer	Enlisted	Civilian
USAF	0	0	103,967	481,882	148,743
USAFR					
Pay group A	7,348	45,439	141	317	12,062
Pay group B	6,192	3,311	0	0	0
ANG	11,918	82,333	656	3,597	24,001

SOURCES: [3], pp. 26-27; [4], p. 8; [5], p.8; [6], Vol. 2, p.22; [7], p. 38; [8], p. 29.

### Pay and Allowances

**Active Force.** The military pay factors include basic pay, incentive and special pay, quarters and subsistence in kind, clothing, terminal leave and severance payments, and employer's social security tax contributions. Table A.7 compares the pay factors for the active personnel as calculated from ARF 173-13 [A.1] and from the Budget Justification [A.3] on an average basis. The results are similar. The cost analysis uses numbers from [A.1] because they are specific to CONUS.

**Civilian.** Civilian pay rates include basic pay, variable payments for overtime, holiday, and cost-of-living allowances, plus the cost of such benefits as retirement, life insurance, and Workmen's Compensation. The active force factors, by major command, are provided in Ref. A.1, Table 3-10, for direct-hire civilian employees. They are \$25,351 for TAC and \$25,583 for MAC.

**Reserve.** The Budget Justifications [A.4, A.5] display total pay and participation rates for officers and enlisted personnel in pay group A

Table A.7  
AIR FORCE ACTIVE PAY FACTORS  
(\$ FY 1983)

	AFR 173-13	Budget Justifications
Rated officer	38,435	38,538
Nonrated officer	34,860	34,961
Rated enlisted	17,194	17,293
Nonrated enlisted	15,873	16,012

SOURCES: [1], p. 37; [3], pp. 10-12.

for inactive drills, active duty tours, and flight training periods. For a general average pay factor, the total pay by category may be divided by the total number of drills (strength \* participation rate). However, this method would ignore the pay differential between rated and non-rated personnel. To account for this pay differential, the total pay must be allocated between the two personnel groups. The budget submissions for the ARF pay group A, shown in Table A.8, provided the basis for the rated and nonrated pay factors.

We first assumed that the inactive drill pay for rated personnel equaled the daily rate for flight training periods (see Table A.8). Multiplying this pay rate by the number of rated personnel, the number of inactive drill periods (48), and the participation rate provided an estimate of the rated personnel portion of the total inactive duty training pay. The remaining portion, assumed to be the nonrated personnel portion, was divided by the total number of drills (48 \* nonrated strength \* participation rate) to yield an average per drill cost for non-rated personnel. The rated and nonrated pay group A personnel strength, provided by the ARF personnel offices, are displayed in Table A.9. The detailed calculations are shown in Table A.10.

Similar calculations provided an estimate of rated and nonrated rates for active duty training periods. We first assumed that the daily pay for rated personnel equaled the flight training rate plus the differential between inactive drill pay and active drill pay. This differential covers subsistence and quarters allowance and is the same for rated and nonrated personnel. It is added to both rated and nonrated active drill pay. The rated and nonrated portions of the total active duty

**Table A.8**  
**AIR RESERVE PERSONNEL BUDGET, FY 1983, PAY GROUP A**  
**(\$ FY 1983)**

	USAFR		ANG	
	Officer	Enlisted	Officer	Enlisted
<b>Active duty training</b>				
Average days	15	15	15	15
Strength	7,348	45,439	11,918	82,333
Participation rate	.964	.930	.861	.936
Total cost (\$000)	11,841	31,737	18,006	64,987
<b>Inactive duty training</b>				
Average drills	48	48	48	48
Strength	7,348	45,439	11,918	82,333
Participation rate	.939	.901	.956	.963
Total cost (\$000)	28,449	73,259	48,465	143,742
<b>Additional flight training</b>				
Total assemblies	106,056	84,996	182,268	53,136
Daily rate (\$)	92.18	44.87	94.21	47.67
Clothing and subsistence (\$000)	90	6,946	213	9,992

SOURCES: For USAFR, [4], pp. 28-31; for ANG, [5], pp. 34-41.

**Table A.9**  
**AIR RESERVE FORCE STRENGTHS, FY 1983,**  
**PAY GROUP A**

	Rated	Ratio <sup>a</sup>	Nonrated	Ratio
<b>USAFR</b>				
Officer	4,335	(.59)	3,013	(.41)
Enlisted	4,271	(.09)	41,168	(.91)
<b>ANG</b>				
Officer	5,125	(.43)	6,793	(.57)
Enlisted	1,647	(.02)	80,686	(.98)

SOURCES: Personnel offices of USAFR and ANG.

<sup>a</sup>The ratio of rated and nonrated to category strength; e.g., 59 percent of reserve pay group A officers are rated and 41 percent are nonrated.

Table A.10  
AIR RESERVE INACTIVE DUTY TRAINING PAY RATES  
(\$ FY 1983)

Variable	USAFR		ANG	
	Officer	Enlisted	Officer	Enlisted
TOTPAY(1) (\$000)	28,449	73,259	48,465	143,742
PAYR(1)	92.18	44.87	94.21	47.67
STRENGTHR	4,335	4,271	5,125	1,647
PARTIC(1)	.939	.901	.956	.963
TOTALPAYR(1) (\$000)	18,011	8,288	21,181	3,630
TOTPAYNR(1) (\$000)	10,488	64,971	27,284	140,113
STRENGTHNR	3,013	41,168	6,793	80,686
PAYNR(1) (\$)	77.23	36.49	87.53	37.57

where

TOTPAY(1) = total inactive duty pay for all personnel  
 TOTPAYR(1) = total inactive duty pay for rated personnel  
 = PAYR(1)\*48\*PARTIC(1)\*STRENGTHR  
 TOTPAYNR(1) = total inactive duty pay for nonrated personnel  
 = TOTPAY(1) - TOTPAYR(1)  
 STRENGTHR = number of rated personnel  
 STRENGTHNR = number of nonrated personnel  
 PARTIC(1) = inactive duty participation rate  
 PAYR(1) = inactive duty pay per drill for rated personnel  
 PAYNR(1) = inactive duty pay per drill for nonrated personnel  
 = TOTPAYNR(1)/(48\*PARTIC(1)\*STRENGTHNR)

SOURCES: [4], pp. 28-29; [5], pp. 34-36.

training costs were then calculated. The calculations and resulting pay rates are shown in Table A.11.

A per capita allowance for clothing, subsistence, and travel was calculated by dividing the total cost (shown in Table A.8, above) by the appropriate personnel strengths.

The pay factors for military personnel are the sum of active duty pay (daily rate \* 15 \* participation rate), inactive duty pay (drill rate \* 48 \* participation rate), additional flight training pay (for rated per-

**Table A.11**  
**AIR FORCE ACTIVE DUTY TRAINING PAY RATES**  
**(\\$ FY 1983)**

<b>Variable</b>	<b>USAFR</b>		<b>ANG</b>	
	<b>Officer</b>	<b>Enlisted</b>	<b>Officer</b>	<b>Enlisted</b>
TOTPAY(2) (\$000)	11,841	31,737	18,006	64,987
PAYR(2)	117.72	57.66	122.57	66.12
STRENGTHR	4,335	4,271	5,125	1,647
PARTIC(2)	.964	.930	.861	.936
TOTPAYR(2) (\$000)	7,379	3,435	8,114	15,289
TOTPAYNR(2) (\$000)	4,477	28,301	10,168	6,346
STRENGTHNR	3,013	41,168	6,793	80,686
PAYNR(2) (\$)	102.77	49.28	115.89	56.02

**where**

TOTPAY(2)	= total active duty pay for all personnel
TOTPAYR(2)	= total active duty pay for rated personnel = PAYR(2)*15*PARTIC(2)*STRENGTHR
TOTPAYNR(2)	= total active duty pay for nonrated personnel = TOTPAY(2) - TOTPAYR(2)
STRENGTH	= number of rated personnel
STRENGTHNR	= number of nonrated personnel
PARTIC(2)	= active duty participation rate
PAYR(2)	= active duty daily pay for rated personnel
PAYNR(2)	= active duty daily pay for nonrated personnel = TOTPAYNR(2)/(15*PARTIC(2)*STRENGTHNR)
PAYR(2)	= PAYR(1) + (PAYR(1) - PAY(1)) (from Table A.10, above)

SOURCES: [4], pp. 28-29; [5], pp. 34-36.

sonnel),<sup>2</sup> and the clothing, subsistence and travel allowance. The final factors are summarized in Table A.1, above.

**Full-Time AGR.** Both the USAFR and the ANG use full-time AGRs; however, there were no AGRs in the units studied. Nevertheless, the pay and allowances for AGRs has been derived as shown in Table A.12.

<sup>2</sup>The number of flight training days per person is equal to the total assemblies in Table A.8 (above) divided by the rated personnel strengths in Table A.9 (above).

**Table A.12**  
**AIR FORCE FULL-TIME RESERVE (AGR) PAY AND ALLOWANCES**  
**(\\$ FY 1983)**

	USAFR		ANG	
	Officer	Enlisted	Officer	Enlisted
<b>Pay and allowances (\$000)</b>				
Full-time training	51,754	27,560	0	0
ANG direct support	0	0	41,792	20,560
ANG training	0	0	44,144	22,361
Weighted average	51,754	27,560	42,227	20,621
Clothing (\$000)	3	32	0	0
Strength	141	317	0	0
Cost per capita (\$)	21	101	0	0
Total AGR pay and allowances (\$000)	51,775	27,661	42,227	20,621

SOURCES: [4], pp. 67-68; [5], pp. 82-84.

NOTE: For the USAFR, pay and allowances includes only the categories of full-time manning. For the ANG, pay and allowances includes only direct unit support and active duty support.

**Civilian.** The USAFR and ANG civilian pay factors, obtained from the appropriate O&M Budget Justification ([A.7], p. 38, and [A.8], p. 29) are \$25,927 for the USAFR and \$28,725 for the ANG.

#### Other Personnel-Related Costs

Other personnel costs cover items not included in the pay cost factor.

**Active Force General Factor.** This category includes permanent change of station (PCS), which equals \$1331 for officers and \$466 for enlisted personnel ([A.1], p. 38, Table 3-7). It also includes civilian travel, which is derived by dividing total O&M travel (\$421 million) by the number of civilians (148,743) and which equals \$2830 ([A.6], Vol. 2, pp. 1, 2, 22).

**Active BOS Nonpay Factor.** This category covers the incremental support costs incurred by the base because the unit is there. It includes medical support, personnel support, base operations, and communications on the basis of an average officer, enlisted person, or civilian. This cost is the sum of medical nonpay and BOS nonpay from

Ref. A.1, CORE model, pp. 106-107. It equals \$3000 for officers, enlisted personnel, and civilians.

**Reserve General Factor.** For the AFR military personnel, this category contains costs that were excluded from personnel pay, including travel, death gratuities, life insurance, and bonuses. These factors were derived from the FY-1985 Budget Justifications [A.4, A.5]. For civilians, this category covers all travel related to civilians in the O&M Budget Justifications divided by total civilians ([A.7], p. 32; [A.8], p. 25). The appropriate costs were divided by force strengths to obtain the per capita factors shown in Table A.13.

**Reserve BOS Nonpay Factor.** A BOS nonpay factor was added to the above per capita factors for the AFR units. An attempt to develop separate factors for the various basing options appropriate to AFR units was precluded by the lack of adequate data. The BOS nonpay factor for AFR personnel was calculated from Refs. A.7 and A.8. The cost of civilians was removed from the budget figures to avoid double counting, since civilian personnel are included in the support personnel strength figures and costed there.

The resulting factors are, however, only estimates of the costs because of the difficulty in separating base-operating-related expenses from aircraft operating expenses. Information from the USAFR and ANG comptroller offices helped to explain the cost split; however, some uncertainty remains concerning the expenses that were included in and excluded from the calculation.

The development of the BOS nonpay factors for ANG and USAFR personnel are shown in Table A.14. Appropriate categories of costs in the Budget Justifications were divided by military and civilian strength to approximate an average per capita cost. ATs are excluded from the military and civilian total to avoid double counting. AT strength is 7,466 for the USAFR and 21,949 for the ANG.<sup>3</sup>

#### **Replacement Acquisition and Training Costs**

Acquisition costs, including travel, recruiting and base training, for officer and enlisted personnel are from Ref. A.1, Table 3-1. For reserve officers, the average of ROTC and OCS schools was used. Acquisition costs are shown in Table A.15.

Separate per capita training cost factors were developed for pilot training, other officer and enlisted aircrew training, and initial skill

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<sup>3</sup>Numbers of ATs are from the Office of Air Force Reserve, Personnel Plans Branch (REPX) and the National Guard Bureau, Personnel Services, Office of Technician Personnel, Data Management.

**Table A.13**  
**AIR RESERVE OTHER PERSONNEL COST FACTOR DERIVATION**  
**(\$ FY 1983)**

	Part-Time		Full-Time		
	Officer	Enlisted	Officer	Enlisted	Civilian
<b>USAFR</b>					
Travel (\$000)	2,559	8,504	159	388	4,631
Strength	7,348	45,439	141	317	12,062
Travel per capita (\$)	348	187	1,128	1,224	384
Death gratuities (\$000)	9	36	9	36	0
Disability (\$000)	329	841	329	841	0
Reserve incentives (\$000)	0	5,613	0	5,613	0
Total (\$000)	338	6,490	338	6,490	0
Strength	13,681	49,067	13,681	49,067	0
Other cost per capita (\$)	25	132	25	132	0
Total cost per capita (\$)	373	319	1,153	1,356	384
<b>ANG</b>					
Travel (\$000)	2,225	5,127	528	547	12,693
Strength	11,918	82,333	656	3,597	24,001
Travel per capita (\$)	187	62	804	152	529
Death gratuities (\$000)	57	60	57	60	0
Disability (\$000)	445	1,146	445	1,146	0
Reserve incentives (\$000)	0	4,441	0	4,441	0
Total (\$000)	502	5,647	502	5,647	0
Strength	12,574	85,930	12,574	85,930	0
Other cost per capita (\$)	40	66	40	66	0
Total cost per capita (\$)	227	128	844	218	529

SOURCES: [4], pp. 11, 12, 68; [5], pp. 11, 84, 85; [7], p. 32; [8], p. 25.

NOTE: Travel budget dollars are divided by the strength in that category, for instance, part-time officer travel budget/number of part-time officers. Other categories of costs (gratuity, disability, and incentive) are divided by part-time plus full-time strengths; these costs are equal for part-time and full-time personnel.

**Table A.14**  
**AIR RESERVE BOS NONPAY FACTORS**  
**(\\$ FY 1983)**

	USAFR	ANG
Mission support (other purchases) (\$000)	0	101,252
Base operations (\$000)	36,267	53,715
Strength	67,344	100,556
Cost per capita (\$)	539	1,541

SOURCES: [7], pp. 21, 26; [8], pp. 10, 20.

NOTE: Civilian salaries have been removed from the budget dollars shown, based on information in the Budget Justifications. Strengths equal all military and civilian personnel minus ATs to avoid the double counting of ATs under both military and civilian categories.

**Table A.15**  
**AIR FORCE PER CAPITA ACQUISITION COST FACTORS**  
**(\\$ FY 1983)**

	Active	USAFR	ANG
<b>Officer</b>			
Acquisition cost (\$)	37,500	16,600	16,600
Nonprior service inductees	--	0	68
Average officer strength	--	14,421	12,574
Turnover factor	.087	0	.005
Cost per capita (\$)	3,263	0	83
<b>Enlisted</b>			
Acquisition cost (\$)	2,600	2,600	2,600
Nonprior service inductees	--	2,811	5,073
Average enlisted strength	--	49,067	85,930
Turnover factor	.164	.057	.059
Cost per capita (\$)	426	148	153

SOURCES: All active, reserve, and guard cost factors are from [1], Table 3-1 or pp. 106, 107. Reserve personnel factors are from [4], pp. 9, 10. Guard personnel factors are from [5], pp. 9, 10.

training. The per capita training factors are based on the average cost of training a person times the number of unit personnel that require training on an annual basis. It is assumed that the per capita training cost is the same for active, reserve, and guard personnel. The aircrew and initial skill training costs are from the CORE model [A.1]. However, the CORE model does not contain the pilot and aircrew training cost for that portion of training provided by the individual commands. This additional cost (extended cost) was included based on information from the TAC and MAC training organizations. The factors are shown in Table A.16.

**Table A.16**  
**AIR FORCE TRAINING COST FACTORS**  
(\$ FY 1983)

	F-4D	C-130E
Pilot	258,269	258,269
Extended pilot	656,000	283,000
Total	914,269	541,269
Other aircrew	60,502	60,502
Extended other aircrew	539,000	177,000
Total	599,502	237,502
Enlisted aircrew	0	14,965
Extended enlisted aircrew	0	44,000
Total	0	58,965
Initial skill, officer	10,489	10,489
Initial skill, enlisted	7,518	7,518

SOURCES: Extended training data are from TAC and MAC training offices; all other are from [1], p. 107.

#### **Replacement Acquisition and Training Turnover Rates**

The active aircrew turnover percentages are also from the CORE model [A.1]. The ARF aircrew percentages were developed from data supplied by the reserve and guard training offices. The initial skill per-

centages for all components are based on the ratio of graduates from Ref. A.10 to the appropriate force strengths for nonrated officers. The development of the turnover factors is shown in Table A.17. Acquisition turnover factors are from Ref. A.1 for the active forces and from Refs. A.4 and A.5 for the reserves. They are based on the losses from each component that are filled with nonprior service personnel divided by average strength. Their derivation is shown in Table A.15, above.

Table A.17  
AIR FORCE ANNUAL TRAINING TURNOVER RATES  
PER CAPITA

	USAF	USAFR	ANG
<b>Pilot training</b>			
Number of graduates	--	60	174
Total number of pilots	--	2,240	3,657
Pilot turnover	.115	.027	.048
<b>Other officer aircrew training</b>			
Number of graduates	--	20	110
Number of other officer aircrew	--	596	1,262
Officer aircrew turnover	.102	.034	.087
<b>Enlisted aircrew training</b>			
Number of graduates	--	(a)	34
Number of enlisted aircrew	--	(a)	1,600
Enlisted aircrew turnover	.164	(a)	.021
<b>Initial skill, officer</b>			
Number of graduates	--	336	376
Number of nonrated officers	--	3,035	6,793
Officer turnover	.074	.111	.055
<b>Initial skill, enlisted</b>			
Number of graduates	--	4,226	5,094
Number of enlisted	--	41,168	80,686
Enlisted turnover	.164	.102	.063

SOURCES: Active aircrew data are from [1], p. 107. Numbers of graduates are from [10], pp. V-4, V-10. Numbers of officers and enlisted aircrew are from the USAFR and ANG training offices. The initial skill strengths are from Table A.9, above.

<sup>a</sup>Reserve values are assumed to equal guard values.

### Other Reserve Training Costs

A further reserve training cost is included for school and special training involving additional paid duty days over and above the normal inactive and active duty periods. The per capita *other* training cost for reserve and guard units is the sum of *career development*, *refresher/proficiency*, and selected *special training* activities spread over the part-time officer and enlisted average strengths. The derivation of the other training cost factors per capita is shown in Table A.18.

Table A.18  
AIR RESERVE OTHER TRAINING COST FACTORS  
(\$ FY 1983)

	USAFR		ANG	
	Officer	Enlisted	Officer	Enlisted
<b>School (\$000)</b>				
Career development	1,588	350	1,269	1,588
Refresher/proficiency	8,406	11,646	4,446	4,023
<b>Special (\$000)</b>				
Exercises	1,126	1,031	4,424	5,909
Operations	12,537	11,137	6,900	4,571
Service mission	1,616	5,581	16,679	6,807
Total (\$000)	25,273	29,745	33,718	22,898
Strength	13,540	48,750	11,918	82,333
Cost per capita (\$)	1,867	610	2,829	278

SOURCES: [4], p. 12; [5], p. 12.

NOTE: Strengths are for part-time military personnel only  
(pay groups A and B).

### EQUIPMENT OPERATING COST FACTORS

Equipment operating costs for aircraft units in the Air Force are readily available in Ref. A.1, which provides both fixed cost per aircraft and variable cost per flying hour (FH) breakouts. Tables A.19 and A.20 summarize the factors for the F-4D and the C-130E. The annual *flying hour* programs for active, USAFR, and ANG units were obtained

from Ref. A.9. The case study used data for TAC F-4D fighters and MAC C-130E airlift missions.

Life-cycle factors, rather than budget-year factors, were used in the model to smooth out year-to-year variances due to the phasing-in and phasing-out of weapon systems. The life-cycle factors are essentially the cumulative average of the budget factors from the time the aircraft is introduced into service until it is phased out of the inventory. The cost factors are the same for active and reserve units, except for POL, which varies by component. We do not know the reason for the reserve's lower POL/FH; it may be that the reserves follow better maintenance or more conservative flying practices than the active forces.

Table A.19  
AIR FORCE F-4D AIRCRAFT FACTORS  
(\$ FY 1983)

	USAF	USAFR	ANG
<b>Aircraft cost factors</b>			
POL/FH	1,734	1,540 <sup>a</sup>	1,540
Base maintenance supplies/FH	240	240	240
Base maintenance supplies/PAA	8,820	8,820	8,820
Depot maintenance/FH	310	310	310
Depot maintenance/PAA	97,020	97,020	97,020
Replenishment spares/FH	322	322	322
Support equipment and spares/PAA	50,375	50,375	50,375
Class IV modifications/PAA	35,220	35,220	35,220
Training ordnance/crew	68,604	68,604	68,604
Total cost per PAA	191,435	191,435	191,435
Total cost per FH	2,606	2,412	2,412
Total cost per crew	68,604	68,604	68,604
<b>Operating tempo (hours/aircraft/year)</b>			
PAA 24	252	202	179
PAA 18	252	217	197

SOURCE: [1], tables 2-2, 2-3, 2-5, 2-6; [9].

<sup>a</sup>[1] provides no USAFR breakout for POL/FH; therefore, the ANG POL/FH figure has been substituted.

## CASE STUDY COST CALCULATION METHODS AND RESULTS

The case study results were calculated using the cost factors and manning levels discussed above and the cost calculation formulas immediately following. Tables A.21, A.22, and A.23 display the case study results.

## AIR FORCE CASE STUDY COST CALCULATION FORMULAS

### PERSONNEL COSTS

#### Military Pay

1. Rated Officer
  - a. (PAA) \* (CR) \* (Pilots/Crew) \* (Rated Officer Pay)
  - b. (PAA) \* (CR) \* (Other Officer Aircrew/Crew) \* (Rated Officer Pay)
  - c. (Supervisory Officers) \* (Rated Officer Pay - Nonrated Officer Pay)
2. (PAA) \* (CR) \* (Enlisted/Crew) \* (Rated Enlisted Pay)
3. (Nonrated Officers) \* (Nonrated Officer Pay)
4. (Nonrated Enlisted) \* (Nonrated Enlisted Pay)
5. (Civilians + Technicians) \* (Civilian Pay)

#### Acquisition

1. (Rated Officers + Nonrated Officers) \* (Officer Acquisition Turnover) \* (Officer Acquisition Cost)
2. (Rated Enlisted + Nonrated Enlisted) \* (Enlisted Acquisition Turnover) \* (Enlisted Acquisition Cost)

#### Training

1. Pilot: (Pilots) \* (Pilot Training Turnover) \* (Pilot Training Cost)
2. Other Rated Officer: (Rated Officers - Pilots) \* (Other Rated Officer Training Turnover) \* (Other Officer Aircrew Training Cost)
3. Rated Enlisted: (Rated Enlisted) \* (Rated Enlisted Training Turnover) \* (Enlisted Rated Training Costs)
4. Initial Skill and Specialty Training
  - a. (Nonrated Officers) \* (Officer Training Turnover) \* (Officer Specialty Training Cost)
  - b. (Nonrated Enlisted) \* (Enlisted Training Turnover) \* (Enlisted Specialty Training Cost)

#### Other Reserve Training (Part-time Personnel Only)

1. (Rated Officers + Nonrated Officers) \* (Other Officer Training Cost)

2. (Rated Enlisted + Nonrated Enlisted) \* (Other Enlisted Training Cost)

Other Personnel Costs

1. (Rated + Nonrated Officers) \* (Other Personnel Costs/Officer)

2. (Rated + Nonrated Enlisted) \* (Other Personnel Costs/Enlisted)

3. ((Civilians) \* (Other Personnel Costs/Civilian)) + ((Technicians) \* (Civilian Travel Costs/Civilian))

Support Personnel

Includes Military Pay, Civilian Pay, Acquisition, Training, Other Reserve Training, and Other Personnel Costs. Support officers and enlisted personnel are not rated. Civilians are costed as civilians, not AT or ART.

EQUIPMENT OPERATION COST CALCULATIONS

POL: PAA \* (FH/PAA) \* (POL Costs/FH)

Aircraft Maintenance Material:

1. PAA \* (FH/PAA) \* (Base Maintenance Material/FH)
2. PAA \* (Base Maintenance Supplies/PAA)

Training Ordnance: PAA \* Crew Ratio \* (Training Ordnance/Crew)

Depot Maintenance:

1. PAA \* (FH/PAA) \* (Depot Maintenance/FH)
2. PAA \* (Depot Maintenance/PAA)

Replenishment Spares: PAA \* (FH/PAA) \* (Replenishment Spares/ FH)

Replacement Support Equipment: PAA \* (Support Equipment/PAA)

Modification Kits: PAA \* (Class IV Mods/PAA)

**Table A.20**  
**AIR FORCE C-130E AIRCRAFT FACTORS**  
**(\\$ FY 1983)**

	USAF	USAFR	ANG
<b>Aircraft cost factors</b>			
POL/FH	788	746	750
Base maintenance supplies/FH	105	105	105
Base maintenance supply/PAA	23,100	23,100	23,100
Depot maintenance/FH	189	189	189
Depot maintenance/PAA	93,870	93,870	93,870
Replenishment spares/FH	217	217	217
Support equipment and spares/PAA	32,802	32,802	32,802
Class IV modifications/PAA	42,660	42,660	42,660
Training ordnance/crew	0	0	0
Total cost per PAA	192,432	192,432	192,432
Total cost per FH	1,299	1,257	1,261
Total cost per crew	0	0	0
<b>Operating tempo (hours/aircraft/year)</b>			
PAA 16	720	--	462
PAA 8	--	467	489

SOURCE: [1], tables 2-2, 2-3, 2-5, 2-6; [9].

**Table A.21**  
**AIR FORCE UNIT OPERATING AND SUPPORT COSTS,**  
**F-4D, PAA 24**  
**(\$ FY 1983 million)**

	USAF	USAFR	ANG
<b>Personnel and support</b>			
Unit pay and allowances			
Officer--part-time	0	0.76	0.79
Officer--full-time	3.27	0	0
Enlisted--part-time	0	1.73	1.51
Enlisted--full-time	10.05	0	0
Civilian	0	7.78	6.52
Total	13.32	10.27	8.82
Other unit personnel and support			
Officer	0.38	0.10	0.18
Enlisted	2.19	0.62	0.95
Civilian	0	0.13	0.12
Total	2.57	0.85	1.25
<b>Unit acquisition and training</b>			
Pilots	3.25	0.74	1.32
Aircrew	1.93	0.61	1.57
Non-aircrew	1.16	0.71	0.38
Other reserve	0	0.64	0.44
Total	6.33	2.70	3.71
Support personnel	2.81	.59	3.07
Total personnel and support	25.03	14.41	16.85
<b>Equipment</b>			
POL	10.49	7.47	6.62
Maintenance supplies	1.66	1.38	1.24
Replenishment spares	1.95	1.56	1.38
Replacement support equipment	1.21	1.21	1.21
Depot maintenance	4.20	3.83	3.66
Modifications	0.85	0.85	0.85
Ordnance	2.06	2.06	2.06
Total equipment	22.41	18.35	17.01
Total unit costs	47.44	32.76	33.86

NOTE: Active and reserve units are colocated on active bases. Guard units are located on commercial fields. Sums may not add because of rounding.

**Table A.22**  
**AIR FORCE UNIT OPERATING AND SUPPORT COSTS,**  
**F-4D, PAA 18**  
**(\$ FY 1983 million)**

	USAF	USAFR	ANG
<b>Personnel and support</b>			
Unit pay and allowances			
Officer--part-time	0	0.60	0.65
Officer--full-time	2.62	0	0
Enlisted--part-time	0	1.56	1.21
Enlisted--full-time	8.29	0	0
Civilian	0	7.16	5.89
Total	10.91	9.32	7.75
Unit other personnel and support			
Officer	0.30	0.08	0.15
Enlisted	1.81	0.55	0.76
Civilian	0	0.12	0.11
Total	2.11	0.75	1.02
Unit acquisition and training			
Pilots	2.44	0.56	0.99
Aircrew	1.45	0.46	1.18
Non-aircrew	0.97	0.65	0.31
Other reserve	0	0.57	0.37
Total	4.86	2.23	2.85
Support personnel	2.29	0.56	2.88
Total personnel and support	20.17	12.86	14.50
<b>Equipment</b>			
POL	7.87	6.02	5.46
Maintenance supplies	1.25	1.10	1.01
Replenishment spares	1.46	1.26	1.14
Replacement support equipment	0.91	0.91	0.91
Depot maintenance	3.15	2.96	2.85
Modifications	0.63	0.63	0.63
Ordnance	1.54	1.54	1.54
Total equipment	16.81	14.41	13.54
Total unit costs	36.98	27.27	28.04

NOTE: Active and reserve units are colocated on active bases. Guard units are located on commercial bases. Sums may not add because of rounding.

**Table A.23**  
**AIR FORCE UNIT OPERATING AND SUPPORT COSTS,**  
**C-130E, PAA 16 AND PAA 8**  
**(\$ FY 1983 million)**

	<b>PAA 16</b>		<b>PAA 8</b>	
	<b>USAF</b>	<b>ANG</b>	<b>USAFR</b>	<b>ANG</b>
<b>Personnel and support</b>				
Unit pay and allowances				
Officer--part-time	0	1.10	0.58	0.65
Officer--full-time	4.39	0	0	0
Enlisted--part-time	0	1.43	0.74	0.80
Enlisted--full-time	6.97	0	0	0
Civilian	0.13	6.87	4.12	3.94
Total	11.49	9.40	5.44	5.39
Other unit personnel and support				
Officer	0.50	.23	0.07	0.14
Enlisted	1.50	.82	0.25	0.47
Civilian	0.03	.13	0.08	0.07
Total	2.03	1.18	0.40	0.68
Unit replacement training				
Pilots	4.19	1.67	0.47	0.83
Aircrew	1.53	0.75	0.17	0.37
Non-aircrew	0.69	0.29	0.27	0.18
Other reserve	0	0.51	0.32	0.32
Total	6.41	3.22	1.23	1.70
Support personnel				
Total personnel and support	1.79	2.59	0.61	2.23
Total personnel and support	21.72	16.39	7.68	10.00
<b>Equipment</b>				
POL	9.08	5.54	2.79	2.93
Maintenance supplies	1.58	1.15	0.58	0.60
Replenishment spares	2.50	1.60	0.81	0.85
Replacement support equipment	0.52	0.52	0.26	0.26
Depot maintenance	3.68	2.90	1.46	1.49
Modifications	0.68	0.68	0.34	0.34
Ordnance	0	0	0	0
Total equipment	18.04	12.40	6.24	6.47
Total unit costs	39.76	28.79	13.92	16.47

NOTE: Active and reserve units are colocated on active bases.  
Guard units are located on commercial bases. Sums may not add because  
of rounding.

## AIR FORCE GLOSSARY

<b>AFR</b>	Air Force regulation
<b>AGR</b>	active guard/reserve
<b>ANG</b>	Air National Guard
<b>ARF</b>	Air Reserve Forces (includes USAFR and ANG)
<b>ART</b>	Air reserve technician
<b>AT</b>	Air technicians (ANG)
<b>BOS</b>	base operating support
<b>CONUS</b>	continental United States
<b>CORE</b>	Cost-Oriented Resource Estimating (model)
<b>CR</b>	crew ratio
<b>FH</b>	flying hours
<b>FH/PAA</b>	flying hours per primary aircraft authorization
<b>IDT</b>	inactive duty training
<b>MAC</b>	Military Airlift Command
<b>MAW</b>	military airlift wing
<b>O&amp;M</b>	operations and maintenance
<b>O&amp;S</b>	operations and support
<b>PAA</b>	primary aircraft authorization
<b>PCS</b>	permanent change of station
<b>POL</b>	petroleum, oil, and lubricants
<b>USAF</b>	U.S. Air Force
<b>USAFR</b>	U.S. Air Force Reserve

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- A.3. Department of the Air Force, *Justification of Estimates for FY 1985, Military Personnel, Air Force*, submitted to the Congress February 1984.
- A.4. Department of the Air Force, *Justification of Estimates for FY 1985, Reserve Personnel, Air Force*, submitted to the Congress February 1984.
- A.5. Department of the Air Force, *Justification of Estimates for FY 1985, National Guard Personnel, Air Force*, submitted to the Congress February 1984.
- A.6. Department of the Air Force, *Justification of Estimates for FY 1985, Operations and Maintenance, Air Force*, submitted to the Congress February 1984.
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- A.9. United States Air Force, DSC/Programs and Resources, Director of Programs and Evaluation, Data Base Management Division (AF/PPPRB), unpublished data, 1983.
- A.10. Department of Defense, *Military Manpower Training Report for FY 1983*, Office of the Assistant Secretary of Defense (Manpower, Reserve Affairs, and Logistics), March 1982.

## **Appendix B**

### **ARMY COST FACTOR DERIVATION**

The development of the factors for estimating the annual O&S costs of the Army active (USA), reserve (USAR), and national guard (ARNG) units, including the appropriate data sources, is described in this appendix. The factors are specifically developed for battalion-level units of mechanized infantry, tank (M60A3), field artillery (155-mm self-propelled), and combat engineer.

This appendix shows the derivation of personnel and equipment cost factors, the necessary cost estimating equations, and the Army case study results. All costs are given in FY 1983 dollars unless otherwise stated. References and a glossary appear at the end of Appendix B.

#### **PERSONNEL COST FACTOR SUMMARY**

Table B.1 shows the cost factors used to estimate personnel and support costs for the four cases studied. The following sections describe the derivation of these factors.

#### **PERSONNEL STRENGTH**

The personnel strength data include the required personnel levels and composition of officers, enlisted, Army technicians<sup>1</sup> (ATs), and full-time active guard/reserves (AGR)s. These data were obtained from the Army *Table of Organization and Equipment* (TO&E) [B.1], and, for the ATs and AGRs, from the Office of the Chief of the Army Reserve (DAAR) and the National Guard Bureau (NGB).

The personnel levels for the various case studies are displayed in Table B.2. The NGB provided both AT and AGR levels; the DAAR could only provide a single level combining both ATs and AGRs. Therefore, the AT and AGR levels provided by the NGB were applied to the reserve. These factors were checked against site specific data from the Georgia and Texas National Guard and from the Reserve Full-Time Unit Support model provided by the Army Forces Command

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<sup>1</sup>Army technicians are civilians during the week and reservists on weekends.

**Table B.1**  
**ARMY PERSONNEL COST FACTOR SUMMARY**  
(\$ FY 1983 per capita)

Cost Factors	USA	USAR	ARNG
<b>Pay and allowances</b>			
Officer	33,053	5,073	5,174
Enlisted	15,252	2,073	2,265
AGR officer	--	36,598	36,285
AGR enlisted	--	21,646	22,199
Civilian	21,986	20,538	26,326
<b>Other personnel costs</b>			
Officer	7,922	1,036	380
Enlisted	6,478	949	433
AGR officer	--	3,699	1,256
AGR enlisted	--	1,561	1,111
Civilian	5,402	1,270	808
<b>Other reserve training</b>			
Officer	--	812	1,214
Enlisted	--	125	124
<b>Replacement training and recruiting<sup>a</sup></b>			
Field artillery			
Officer	2,607	223	441
Enlisted	2,393	1,350	1,597
Tank			
Officer	2,854	245	484
Enlisted	3,527	2,037	2,500
Engineer			
Officer	1,949	166	326
Enlisted	2,712	1,544	1,836
Infantry			
Officer	1,673	142	278
Enlisted	2,485	1,406	1,666

NOTE: AGR = active guard/reserve (full-time).

<sup>a</sup>Training cost per capita = (training cost + recruiting cost) \* (turnover factor).

(FORSCOM). The AGRs and ATs assigned to a battalion are included in the TO&E requirement as military personnel.

The TO&E requirements were chosen as a data source to ensure the costing of comparably staffed and equipped units. TO&E requirement statements are expressed at various readiness levels, called authorized

**Table B.2**  
**ARMY UNIT PERSONNEL STRENGTHS**

	ALO 1		ALO 2	
	Active	Reserve	Active	Reserve
<b>Field artillery battalion</b>				
Officer	29	29	29	29
Enlisted	480	480	448	448
(AT enlisted)	(0)	(4)	(0)	(4)
(AGR officer)	(0)	(2)	(0)	(2)
(AGR enlisted)	(0)	(21)	(0)	(21)
<b>Tank battalion</b>				
Officer	37	37	35	35
Enlisted	496	496	462	462
(AT enlisted)	(0)	(3)	(0)	(3)
(AGR officer)	(0)	(2)	(0)	(2)
(AGR enlisted)	(0)	(11)	(0)	(11)
<b>Engineer battalion</b>				
Officer	43	43	43	43
Enlisted	799	799	724	724
(AT enlisted)	(0)	(4)	(0)	(4)
(AGR officer)	(0)	(0)	(0)	(0)
(AGR enlisted)	(0)	(15)	(0)	(15)
<b>Infantry battalion</b>				
Officer	42	42	42	42
Enlisted	832	832	680	680
(AT enlisted)	(0)	(2)	(0)	(2)
(AGR officer)	(0)	(2)	(0)	(2)
(AGR enlisted)	(0)	(15)	(0)	(15)

SOURCES: For all military personnel, [1]. Data on AT (Army technician) and AGR levels were obtained from the Office of Requirements and Documentation, National Guard Bureau.

level of organization (ALO). These ALOs relate to the strength or fill rate of the unit. In the case study analysis, units are compared at equivalent ALO 1 and ALO 2, with ALO 1 representing a unit with 100 percent and ALO 2 a unit with 90 percent of its required wartime equipment and personnel.

## PER CAPITA COST FACTORS

Per capita factors include values for military and civilian pay and allowances, individual replacement acquisition and training costs, and base operating support (BOS) costs. These factors in combination with unit personnel levels yield the personnel costs for a unit. The factors are arrived at by an average cost approach based on costs and manpower strengths shown in the Budget Justifications [B.2-B.4]. Table B.3 shows the average personnel strengths used in the derivation of the factors.

### Active Pay and Allowances

**Military.** For the USA, pay and allowances were derived from the Budget Justification [B.2] by dividing the total pay for officer and enlisted by the average officer and enlisted strength. The cost categories included in the active personnel pay factor are shown in Table B.4. Flight pay is not included because the case studies contained no aircraft units. Separation pay and death gratuities for active personnel are included in this pay factor.

**Civilian.** The civilian pay factor for the USA is \$21,986 [B.5, pp. I-12, 13]. This is the sum of direct and indirect hire compensation

Table B.3  
ARMY AVERAGE PERSONNEL STRENGTHS, 1983

	Part-Time		Full-Time		
	Officer	Enlisted	Officer	Enlisted	Civilian
USA	0	0	103,842	670,747	253,111
USAR					
Pay group A	39,007	192,139	2,111	4,965	12,627
Pay group D	7,669	681	0	0	0
ARNG	38,895	331,578	1,917	10,387	22,857

SOURCES: [2], p. 6; [3], p. 4; [4], p. 6; [5], pp. I-11, I-12; [6], p. 36; [7], p. 1.

Table B.4  
USA PERSONNEL PAY FACTORS  
(\$ FY 1983)

	Officer	Enlisted
Basic pay (\$000)	2,642,316	7,158,411
Quarters (\$000)	290,967	850,676
Housing (\$000)	54,374	152,380
Subsistence (\$000)	122,330	967,247
Incentive pay (\$000)	4,102	25,370
Special pay (\$000)	90,620	214,896
Allowances (\$000)	30,883	293,011
Separation (\$000)	25,373	83,639
Social Security (\$000)	170,909	479,779
Other (\$000)	456	4,694
Total pay (\$000)	3,432,330	10,230,103
Average strength	103,842	670,747
Pay per capita (\$)	33,053	15,252

SOURCE: [2], pp. 12-15.

divided by average direct and indirect civilian strength. The USA case study units contained no civilians.

#### Reserve Pay and Allowances

**Part-Time Reserve.** For the USAR and the ARNG part-time reserves, the Budget Justifications [B.3, B.4] display pay and allowances for pay group A officers and enlisted on active and inactive duty training. These include basic pay, Social Security, subsistence, quarters allowances, and special and incentive pay; they do not include flight pay. An average pay factor was developed by dividing the total cost for pay group A by the average strength for pay group A. Similarly derived factors were added for clothing and subsistence allowances. The ARF pay factors are displayed in Table B.5. Death gratuities and hospitalization are not included; these costs are captured under other personnel costs.

Table B.5  
ARMY RESERVE PERSONNEL PAY FACTORS, PAY GROUP A  
(\$ FY 1983)

	USAR		ARNG	
	Officer	Enlisted	Officer	Enlisted
<b>Pay and allowances (\$000)</b>				
Inactive duty training	142,231	259,640	139,318	467,941
Active duty training pay	54,856	105,605	60,918	215,226
Clothing	794	18,627	1,000	32,047
Subsistence	0	14,387	0	35,852
Total	197,881	398,259	201,236	751,066
Average strength	39,007	192,139	38,895	331,578
Pay per capita (\$)	5,073	2,073	5,174	2,265

SOURCES: [3], pp. 30-34; [4], pp. 22-26.

**Full-Time Reserve.** The AGR pay factor for full-time active duty reservists was also derived from the Budget Justifications. The pay rate for full-time manning and conversion to technicians for officers and enlisted are displayed under Administration and Support, Pay and Allowances, in the Budget Justifications. These rates include basic pay, Social Security, subsistence, quarters, and special and incentive pay (see Table B.6). In some cases, the rates given for full-time manning and conversion to technicians varied slightly. In these cases, a weighted average of the two rates was used.

**Civilian.** Civilian personnel pay factors for the USAR and ARNG technicians were extracted from the Operations and Maintenance Budget Justifications [B.6, B.7]. They are \$20,538 for USAR civilians [B.6, p. 36] and \$26,326 for ARNG civilians [B.7, p. 35].

#### Other Personnel Costs

Other personnel costs include categories of benefits not covered in pay and allowances plus the portion of support costs attributable to the unit (BOS nonpay). The general category includes cost factors for travel and for reserve medical and reenlistment bonuses. BOS nonpay

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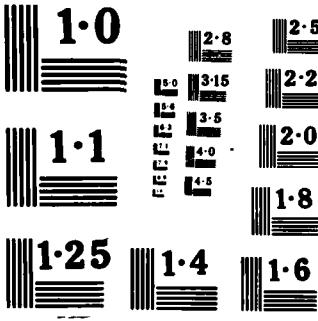
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**Table B.6**  
**ARMY FULL-TIME RESERVE (AGR) PAY FACTORS**  
**(\$ FY 1983)**

	USAR		ARNG	
	Officer	Enlisted	Officer	Enlisted
Full-time manning rate	35,643	20,938	34,721	21,961
Conversion of technicians to full-time manning rate	38,447	22,840	36,834	22,340
Weighted average factor	36,598	21,646	36,285	22,199

SOURCES: [3], p. 77; [4], pp. 59-61.

includes costs from the O&M accounts for base operations, such as civilian support personnel pay, utilities, communications, and security patrols. Table B.7 shows the resulting factors; a description of their derivation follows:

**General Active.** The USA Other Personnel Costs include only travel as found in the Budget Justifications under Permanent Change of Station (PCS): \$261,692 for officers and \$721,846 for enlisted [B.2, p. 15]. The PCS factor, derived by dividing the total budget PCS category by average strength, equals \$2520 for officers and \$1076 for enlisted.

**General Reserve.** General personnel cost factors for reserve officers and enlisted, AGRs, and civilians include all personnel costs not included in the personnel pay factors. For both full-time and part-time military personnel, this includes travel, death gratuities, disability, hospitalization, and reenlistment and incentive bonuses. These factors were developed by dividing total budget dollars by average strength. Travel is derived by dividing the specific costs associated with each pay group by the strength of that pay group, as shown in Table B.8. The other costs are distributed over pay groups A, B, and D and the full-time manning strengths as shown in Table B.9.

Civilian travel costs are taken from the ARNG O&M Budget Justification [B.7]. The USAR does not track these costs. The ARNG shows technician school travel (\$4,058,000) and technician travel (\$8,923,000) in [B.7, pp. 9, 13]. This total is divided by the number of

Table B.7  
ARMY OTHER PERSONNEL COST FACTORS  
(\$ FY 1983)

	USA	USAR	ARNG
<b>BOS nonpay</b>			
Officer	5,402	702	240
Enlisted	5,402	702	240
AGR officer	0	702	240
AGR enlisted	0	702	240
Civilian	5,402	702	240
<b>PCS, travel</b>			
Officer	2,520	285	100
Enlisted	1,076	135	43
AGR officer	0	2,948	976
AGR enlisted	0	747	721
Civilian	0	568	568
<b>Other</b>			
Officer	0	49	40
Enlisted	0	112	150
AGR officer	0	49	40
AGR enlisted	0	112	150
Civilian	0	0	0
<b>Total</b>			
Officer	7,922	1,036	380
Enlisted	6,478	949	433
AGR officer	0	3,699	1,256
AGR enlisted	0	1,561	1,111
Civilian	5,402	1,270	808

ARNG civilians for an average travel factor of \$568. We apply this factor to both ARNG and USAR civilians.

**Active BOS Nonpay.** The unit base support costs were developed on a per capita basis. The BOS nonpay factor aggregates several cost categories. Base operations and real property maintenance for CONUS-based forces are averaged over CONUS-based personnel, both military and civilian. The relevant communication, medical, and morale costs are summed and averaged over the force. The sum of these two operations (\$5402), representing both military and civilian BOS nonpay costs, is shown in Table B.10.

**Table B.8**  
**ARMY RESERVE TRAVEL COST FACTOR DERIVATION**  
**(\$ FY 1983)**

	Part-Time		AGR	
	Officer	Enlisted	Officer	Enlisted
<b>USAR</b>				
Travel (\$000)	11,107	25,984	6,224	3,708
Strength	39,007	192,139	2,111	4,965
Travel per capita (\$)	285	135	2,948	747
<b>ARNG</b>				
Travel (\$000)	3,889	14,340	1,872	7,486
Strength	38,895	331,578	1,917	10,387
Travel per capita (\$)	100	43	976	721

SOURCES: [3], pp. 35,78; [4], pp. 10, 61.

**Table B.9**  
**ARMY RESERVE OTHER GENERAL COST FACTOR DERIVATION**  
**(\$ FY 1983)**

	Officer	Enlisted
<b>USAR</b>		
Death gratuities (\$000)	77	112
Hospitalization and disability (\$000)	2,310	2,635
Reenlistment incentives (\$000)	0	19,457
Total (\$000)	2,387	22,204
Strength	48,787	197,785
Other per capita (\$)	49	112
<b>ARNG</b>		
Death gratuities (\$000)	18	70
Hospitalization and disability (\$000)	1,599	10,179
Reenlistment incentives (\$000)	0	41,183
Total (\$000)	1,617	51,432
Strength	40,812	341,965
Other per capita (\$)	40	150

SOURCE: [3], p. 15; [4], p. 12.

Table B.10  
USA BOS NONPAY COST FACTOR DERIVATION  
(\$ FY 1983)

Base support (\$000) <sup>a</sup>	
Base operations	635,767
Real property maintenance	548,252
Total base support (\$000)	1,184,019
Strength	293,026
Base support per capita (\$)	4,041
Other activities (\$000)	
Intelligence and communications	
Base communications	194,755
Long-haul communications	328,542
Medical	
Care in regional facilities	286,802
Station hospitals	436,535
Dental care	58,044
Care in non-Defense facilities	61,991
Other personnel activities	32,228
Total other activities (\$000)	1,398,897
Strength	1,027,700
Other activities per capita (\$)	1,361
BOS nonpay per capita (\$)	5,402

SOURCE: [5], pp. i, ii, iii, I-1.

<sup>a</sup>Based on general purpose forces, CONUS.

It is currently not possible to adequately separate fixed from variable BOS costs or to separate equipment-related from personnel-related support costs. We therefore aggregated the various types of support-related costs into a single factor. As better data become available, they should be incorporated into the cost-estimating methodology.

**Reserve BOS Nonpay.** We developed equivalent factors for the USAR and ARNG by extracting like categories of costs from the Budget Justifications operations and maintenance accounts (OMA) and dividing by the number of personnel (military and civilian). Real property maintenance and morale activities are found under base operations in the reserve budgets. The differences in categories between the USAR and ARNG reflect the level of detail available in the budget. The results, shown in Table B.11, apply to military and civilian personnel.

**Table B.11**  
**ARMY RESERVE BOS NONPAY COST FACTOR DERIVATION**  
**(\\$ FY 1983)**

	USAR	ARNG
Base operations (\$000)	169,331	45,015
Communications (\$000)	12,554	8,805
Medical support (\$000)	--	8,008
Transportation (\$000)	--	12,470
Other supplies and services (\$000)	--	23,155
Total (\$000)	181,885	97,453
Strength	259,199	405,634
BOS nonpay per capita (\$)	702	240

SOURCES: [6], p. 2; [7], pp. 13, 17.

#### Replacement Acquisition and Training Costs

Training cost factors were developed for officer and enlisted personnel. Four separate cost factors were considered: recruiting costs, pay and allowances during basic and MOS training (military personnel appropriation—MPA), operations and maintenance of training facilities in support of trainees (OMA), and ammunition used during training (AMMO). The MPA, OMA, and AMMO costs are assumed equal for active, reserve, and guard personnel undergoing school training. That is, the cost to send a trainee through basic and MOS training is the same no matter what the trainee's component.

The *Army Force Planning Cost Handbook* (AFPCH) [B.8] estimates the MPA, OMA, and AMMO training costs of a unit by multiplying the number of personnel in each MOS by the appropriate costs from the *MOS Cost Handbook* and TRADOC inputs that display the training cost per student for each MOS code or course. The AFPCH Force Cost Information System (FCIS) [B.8, Section III] displays (1) the formulas used in these calculations for recurring and nonrecurring costs and (2) the resulting unit costs when the formulas are applied. Using the final unit costs from the AFPCH and the number of officers and enlisted personnel from the TO&E, we can solve the AFPCH formulas for the average training cost per officer and enlisted personnel for each type unit.

Each type of battalion has different cost factors. For instance, the MOS training costs more for a tank battalion than for a nonmechanized infantry battalion, owing to the more costly training needed for tank operations. These cost factors include all MPA costs from basic through MOS completion. In addition, the FCIS adds to the training MPA (1) separation costs and (2) the costs of accession, travel, and initial clothing for trainees. The second factor, added to all (active and reserve) training MPA, equals \$2267 for officers and \$1058 for enlisted [B.8, p. III-23]. The separation cost has already been applied to the active in their MPA cost factor and does not apply to reserve personnel. Table B.12 shows the values derived for the four battalions examined. All costs from the AFPCH were multiplied by 1.07 to arrive at FY 1983 dollars.

**Table B.12**  
**USA TRAINING COST FACTORS PER CAPITA**  
**(\$ FY 1983)**

	Officer	Enlisted
<b>Field artillery</b>		
MPA	20,932	6,920
OMA	6,200	1,642
AMMO	3,884	138
Total	31,016	8,700
<b>Tank</b>		
MPA	22,461	9,903
OMA	6,950	2,459
AMMO	4,693	1,205
Total	34,104	13,567
<b>Engineer</b>		
MPA	16,449	7,859
OMA	5,045	1,692
AMMO	1,293	518
Total	22,787	10,069
<b>Infantry</b>		
MPA	13,662	7,006
OMA	5,069	1,807
AMMO	611	280
Total	19,342	9,093

SOURCE: [8], pp. 21-27, and II-23.

Similar exercises were performed for the OMA and AMMO training costs. Again, the cost factors vary by type of battalion, but not among services.

The AFPCH training costs do not include recruiting costs. The Budget Justifications of each service contain both pay and allowances of recruiters and some O&M costs associated with recruiting. These costs have been summed and divided by total gains to get an average cost per recruit (see Table B.13). This cost is used with the turnover rates developed below in calculating total replacement training costs. The costs vary by component, but not by unit.

The active budget does not have a military recruiter MPA breakout. The O&M Budget Justifications do, however, show total military man-years involved as 916 for officers and 8740 for enlisted [B.5, p. 87-26]. These numbers have been multiplied by average officer and enlisted pay and allowances to approximate active recruiting MPA.

#### **Replacement Acquisition and Training Turnover**

Turnover factors were developed using the Personnel Budget Justifications. The factors are based on losses (minus reenlistment losses). For the active, losses minus reenlistments are averaged over officer and enlisted strengths to arrive at turnover rates. A similar calculation is done for reserves, which, however, train only nonprior service (NPS)

**Table B.13**  
**ARMY RECRUITING COST FACTOR DERIVATION**  
(**\$ FY 1983**)

	USA	USAR	ARNG
Recruiting and retention, MPA (\$000)	163,579 <sup>a</sup>	4,122	2,362
Recruiting, AGR officers (\$000)	0	8,652	6,031
Recruiting, AGR enlisted (\$000)	0	37,631	59,452
Recruiting, OMA (\$000)	232,945	39,808	12,817
Total (\$000)	396,524	90,213	80,662
Personnel losses (\$000)	252,381	102,709	167,850
Recruiting per capita (\$)	1,571	878	481

SOURCES: [2], pp. 10, 11; [3], pp. 11, 12, 65, 77; [4], pp. 8, 9, 47, 59, 60; [5], pp. I-4, 86-26; [6], p. 25; [7], p. 25.

<sup>a</sup>Number of USA personnel involved in recruiting multiplied by average pay factors [5], p.86-26.

individuals. Thus, the losses-to-strength ratio must be modified to reflect only nonprior service replacements. This is done by multiplying the losses-to-strength ratio by the NPS service accessions to total gains (minus reenlistment) ratio. The derivation of the turnover factors is shown in Table B.14.

Table B.14  
ARMY PERSONNEL TURNOVER FACTOR DERIVATION

	Officer	Enlisted
<b>Losses<sup>a</sup></b>		
USA	8,353	156,427
USAR	8,071	54,054
ARNG	4,844	81,873
<b>Average strength</b>		
USA	103,842	670,747
USAR	48,787	197,785
ARNG	40,812	341,965
<b>Ratio</b>		
USA	.080	.233
USAR	.165	.273
ARNG	.119	.239
<b>Nonprior service gains</b>		
USA	--	--
USAR	411	33,241
ARNG	738	65,645
<b>Total gains<sup>a</sup></b>		
USA	--	--
USAR	9,653	64,344
ARNG	6,257	89,878
<b>Ratio</b>		
USA	--	--
USAR	.043	.517
ARNG	.118	.730
<b>Turnover</b>		
USA	.080	.233
USAR	.007	.141
ARNG	.014	.174

SOURCES: [2], pp. 10-11; [3], pp. 11-12;  
[4], pp. 8-9.

<sup>a</sup>Minus reenlistments for enlisted personnel.

### Other Reserve Training

The category of other reserve training costs applies only to the reserve and covers the pay and allowances for man-days over the normal 15 active and 48 inactive drills. This category captures costs associated with retraining prior-service gains or additional days associated specifically with unit-level training. All training cost factors are on a dollars per officer or dollars per enlisted basis.

We developed other reserve training cost factors from the Budget Justifications [B.3, B.4], using the categories of school training and special training. We did not include training related to headquarters support, specialized medical skills, or unit conversion because these categories do not apply to the battalions chosen or are not included in the model. Also not included are cost categories covered under basic and MOS replacement training, such as initial skill acquisition. Table B.15 shows the derivation of these factors.

Table B.15  
ARMY RESERVE OTHER TRAINING FACTOR DERIVATION  
(\$ FY 1983)

	USAR	ARNG		
	Officer	Enlisted	Officer	Enlisted
<hr/>				
School (\$000)				
Career development	10,141	5,460	9,831	6,285
Refresher/proficiency	5,707	5,705	17,149	21,826
Special (\$000)				
Exercises	5,697	3,686	9,304	5,181
Operations	9,961	8,941	2,805	4,750
Service/mission	159	291	0	0
Training with active	0	0	8,135	3,191
Total (\$000)	31,665	24,083	47,224	41,233
Strength	39,007	192,139	38,895	331,578
Cost per capita (\$)	812	125	1,214	124

SOURCE: [3], p. 14; [4], pp. 14-15.

## EQUIPMENT OPERATING COST FACTORS

After personnel costs, the second major category of a unit's annual operating and support costs arises from the operation and maintenance of the unit's equipment. The ideal approach to estimating equipment operating cost would resemble that used for unit personnel cost. Cost factors would be developed for the various types of equipment in the unit inventory and then applied to the quantity of equipment and peacetime operating tempo of the equipment to yield the unit's equipment O&S cost. Unfortunately, the nature of the peacetime operations of active and reserve Army units and the lack of a suitable data system to track equipment expenses do not permit the use of this estimating approach. We describe below the problems of estimating these costs for a typical unit in Army active and reserve components.

### Problems of Estimating Equipment Cost

The ideal approach would embody two important assumptions regarding the homogeneity of the factors and the availability of the data. Unfortunately, for Army (nonflying unit) equipment cost estimating, neither of these assumptions holds.

Programmed operating factors (except for aircraft) do not specify the number of miles or hours that equipment should be operated for any level of unit priority. Since there are no measures of training tempo, units exercise their equipment based on a number of factors, including access to training facilities, past proficiency ratings, scheduling for the National Training Center, scheduling for special training (cold or tropical weather training), the commander's predisposition for certain types of training, and the available budget. Therefore, the operating tempo varies, sometimes dramatically, from unit to unit and from year to year for a given unit. No standard factor applies.

The second main problem area in Army equipment cost estimation involves the lack of adequate data to develop the operating cost factors. Although a few cost collection or display systems are used by active units, these are usually tailored by the individual operating locations. The lack of standardization makes comparisons between units difficult. The systems also usually track costs at a higher than battalion level—typically, the division. Finally, historical equipment cost data are not maintained; a new fiscal year typically means that all previous cost data are expunged from the system. For reserve and guard units, costs either are not collected or are collected manually.

Reserve and guard units often do not physically have their full complement of equipment. Budget shortfalls result in insufficient quanti-

ties to fully equip all units. Reserve force equipment may be pre-positioned or consolidated at operating locations. As a result, various units share the same pool of equipment and usually no attempt is made to associate costs back to the individual units. Equipment may also be shared by active and ARF units.

The problem of associating centralized costs with individual units also occurs at the division- and corps-level supply and maintenance organizations. The centralized organization supports many units and often does not, or cannot, track their part and labor allocations to the units that it supports.

The above factors result in the absence of the data needed to estimate a unit's equipment operating expenditures by considering the fixed and variable costs of the unit's equipment. Lacking the detail necessary for a bottom-up estimate, an alternative would be a top-down approach. But this aggregate method faces similar problems, including the lack of cost data at the battalion level and the allocation of centralized maintenance and support costs to individual units.

Because of these shortcomings, we had to base the equipment operating cost estimates for the case studies on actual operating data received from active installations and National Guard units. The combining of site-specific equipment data with notional personnel data violates an assumption of the cost estimating model. The resulting costs are not notional. Nevertheless, data constraints left no other choice. Rather than offer no comparison at all, we used the site-specific equipment data, recognizing that it may misrepresent a notional unit. The remainder of this subsection describes those data and their limitations in providing estimates of active and reserve force O&S cost estimates.

### **Approach**

The sparseness of typical equipment operating cost data in the Army forced us to use site-specific, year-specific data for estimating the annual operating and support costs of active and ARF units. Because existing equipment cost reporting systems are tailored by the using installations, we had to pick installations with complete data systems and with comparable (same ALO) active and reserve units. After discussions with the Comptroller's Office at FORSCOM, we chose the Tactical Unit Financial Management Information System (TUFMIS) as the data system best suited to the analysis because it tracks several cost categories at the battalion level.

Forts Hood and Stewart were chosen as the active installations to be sampled. Fort Hood uses a well-developed accounting system and has

attempted unit cost and life-cycle cost factor development. The nearby Texas National Guard has several typical guard units that are not undergoing drastic modernization. The Georgia National Guard roundout unit is attached to Ft. Stewart, and we were thus able to compare an active and a guard unit with approximately the same operating tempo and priority.<sup>2</sup>

Table B.16 displays the types of costs available from the sites examined. The active installation data are based on the TUFMIS, except for the ammunition data, which are from the Training Ammunition Management Information System (TAMIS). National Guard costs are from each state's own accounting system, except for ammunition costs from TAMIS.

Table B.16  
AVAILABILITY OF USA AND ARNG SITE-SPECIFIC COST DATA

	Fort Hood	Texas ARNG	Fort Stewart	Georgia ARNG
Fuel	Yes	Yes	Yes	Yes
Ammunition	Yes	Yes	No	Yes
Repair parts (PLL and ASL)	Yes	Yes	Yes	Yes
Other organizational material	Yes	Partial	Yes	Yes
Higher level maintenance				
Direct support				
Parts	Yes	Yes	Yes	Yes
Man-hours	No	Partial	No	No
General support				
Parts	No	No	No	No
Man-hours	No	No	No	No
Depot				
Parts	No	No	No	No
Man-hours	No	No	No	No

SOURCES: Ft. Hood--Comptroller's Office, 1st Cavalry Division, Ft. Hood; Texas National Guard--State Maintenance Officer and U.S. Fiscal and Property Officer, Texas National Guard, Camp Maybry, Austin, Texas; Ft. Stewart--Comptroller's Office, FORSCOM, Ft. McPherson, Georgia; Georgia National Guard--State Maintenance Office, Georgia National Guard, Atlanta, Georgia.

<sup>2</sup>The Georgia National Guard roundout units are in a state of flux because of the newness of the roundout program. Thus, the costs may not be typical; however, they do suggest the high end of the range for equipment-related costs.

We found the following comparability problems:

**Fuel.** Fuel is tracked on a bulk and package basis or on a motor gasoline (MOGAS) and diesel basis. The data appear to have been collected on a comparable basis and include all unit POL costs.

**Ammunition.** Ammunition costs are tracked separately from other organizational costs on the TAMIS. The active and guard figures on expended ammunition per fiscal year appear to have been collected on a comparable basis.

**Repair Parts.** The two active units appear to track these costs similarly under Class IX, Repair Parts, which includes both Prescribed Load List (PLL) and Army Stock List (ASL) items. The guard seems to track repair costs similarly at the two sites. Some portion of the cost of direct support and general support repair parts is included in the data because of the accounting method. The Georgia National Guard could supply PLL data by type of battalion, but ASL cost only on a brigade basis. We divided the brigade total of \$2,414,940 by four, the number of battalions in the brigade, to arrive at an ASL cost per battalion of \$603,735.

**Other Organizational Material.** The active units provided "other" organizational equipment costs (classes II, IV, and VII), but the guard units were unable to provide this information. To arrive at a guard cost, we applied the ratio of guard to active costs for fuel, ammunition, and repair parts to the active unit other organizational equipment costs.

**Man-Hours.** Maintenance man-hours at the organizational level are included under personnel costs. The Texas Guard provided an estimate of maintenance man-hours at the direct support mobilization, training, and equipment sites (MATES). Other sites could not provide these data; therefore, we could not include higher-level maintenance man-hours in the estimates.

**Depot Maintenance.** None of the sites could provide depot maintenance parts or man-hours; therefore, this category of costs has not been included in the analysis.

**Completeness.** The ability to provide data for the various units under study varied from site to site. For instance, the Texas Guard could not give us information on a combat engineer unit.

**Authorized Levels of Organization.** The ALOs of units varied across sites. The Texas Guard's mechanized infantry and tank battalions, for example, are at ALO 3, while the Ft. Hood units are all at ALO 2. In comparing sites, we put the equipment costs of the units being compared on similar ALOs by multiplying the costs by appropriate factors. For instance, we multiplied the Texas Guard unit equip-

ment costs by 1.125 (90 percent for ALO 2 divided by 80 percent for ALO 3) to equate them (approximately) with the Ft. Hood battalion costs. The personnel strengths for various ALO levels were extracted from the appropriate TOEs.

**Years Compared.** Different installations kept records differently. The Georgia Guard kept information on a calendar year basis. The other installations used fiscal years. Unless otherwise indicated, all equipment costs used in this study are in FY 1982 dollars. When used with personnel costs, these figures are updated to FY 1983 dollars using the 1.07 inflation factor provided by FORSCOM.

#### **DERIVATION OF FACTORS**

We present below the actual equipment operating data received from active and guard installations and the inferences drawn from these data. The reader should consider the equipment operating costs in the case studies to be initial, rough estimates. Further efforts in establishing and monitoring adequate equipment cost collection systems are required before suitable estimates of battalion-level equipment O&S costs can be developed. Table B.17 displays the equipment cost data from the sites and units examined. They do not include maintenance man-hours beyond the unit level or depot maintenance costs.

The Georgia equipment factors appear to be erratic. In some cases, the Georgia Guard costs are greater than those of the Georgia active and the Georgia active is sometimes less than the Texas active. Both results are surprising. However, after further discussions with ANG offices, we conclude that the Georgia Guard data are misleading. First, equipment from the Georgia units is often used by other units without proper accounting. Second, the Georgia units were in transition, preparing for a tour at the National Training Center. The problems with the Georgia data lead us to rely for our costing on the Texas data, which appear to be based on a more stable program.

#### **CASE STUDY COST CALCULATION METHODS AND RESULTS**

The case study results were calculated using the cost factors and manning levels discussed above and the cost calculation formulas immediately following. Tables B.18, B.19, B.20, and B.21 display the case study results.

**ARMY CASE STUDY COST CALCULATION FORMULAS****PERSONNEL COSTS****Military Pay**

1. (Officers - AGR Officers) \* (Officer Pay)
2. (Enlisted - AGR Enlisted) \* (Enlisted Pay)
3. (AGR Officers) \* (AGR Officer Pay)
4. (AGR Enlisted) \* (AGR Enlisted Pay)

Civilian Pay: (Civilians + AT) \* (Civilian Pay)

**Recruitment**

1. (Officers) \* (Officer Turnover Rate) \* (Officer Recruitment Cost)
2. (Enlisted) \* (Enlisted Turnover Rate) \* (Enlisted Recruitment Cost)

**Training (Including Basic, Initial Skill, and Specialty)**

1. (Officers) \* (Officer Turnover) \* (Officer Training Cost)
2. (Enlisted) \* (Enlisted Turnover) \* (Enlisted Training Cost)

**Other Reserve Training (Part-time Personnel Only)**

1. (Officers - AGR Officers) \* (Other Officer Training Costs)
2. (Enlisted - AGR Enlisted) \* (Other Enlisted Training Costs)

**Other Personnel Costs**

1. (Officers - AGR Officers) \* (Other Personnel Costs/Officer)
2. (Enlisted - AGR Enlisted) \* (Other Personnel Costs/Enlisted)
3. (AGR Officer) \* (Other Personnel Cost/AGR Officer)
4. (AGR Enlisted) \* (Other Personnel Cost/AGR Enlisted)
5. (Civilians - AT) \* (Other Personnel Costs/Civilian)

**EQUIPMENT OPERATION COSTS**

All costs are fixed

Table B.17  
ARMY BATTALION EQUIPMENT COST DATA

	Georgia (ALO 1)		Texas (ALO 2)	
	USA (\$FY83)	ARNG (\$CY82)	USA (\$FY82)	ARNG <sup>a</sup> (\$FY82)
<b>Fuel</b>				
Field artillery	59,361	81,358	57,476	13,600
Tank	122,646	89,344	138,173	42,806
Engineer	78,353	77,062	111,625	--
Infantry	84,033	112,403	64,807	42,806
<b>Ammunition</b>				
Field artillery	1,292,749	454,770	1,566,241	310,641
Tank	2,307,120	708,276	1,624,011	384,165
Engineer	69,605	41,218	146,668	--
Infantry	1,058,077	194,627	969,419	214,822
<b>Repair parts</b>				
Field artillery	533,194	751,630	436,242	150,075
Tank	818,546	724,289	1,188,323	226,350
Engineer	540,878	728,980	953,476	--
Infantry	540,283	666,790	657,925	195,806
<b>Total</b>				
Field artillery	1,885,304	1,287,758	2,059,959	474,316
Tank	3,248,312	1,521,909	2,950,507	653,321
Engineer	688,836	847,260	1,211,769	--
Infantry	1,682,393	973,820	1,692,151	453,434
<b>Other equipment<sup>b</sup></b>				
Field artillery	458,000	312,814	132,450	30,464
Tank	409,234	191,301	177,000	39,117
Engineer	361,045	444,085	237,000	--
Infantry	464,074	268,699	185,950	49,835
<b>Total equipment</b>				
Field artillery	2,343,304	1,600,572	2,192,409	504,780
Tank	3,657,546	1,713,210	3,127,507	692,438
Engineer	1,049,881	1,291,345	1,448,769	--
Infantry	2,146,467	1,242,519	1,878,101	503,269

<sup>a</sup>Actual data multiplied by a factor of 1.125 to estimate ALO 2 costs.

<sup>b</sup>Guard other equipment cost is estimated by applying the guard-to-active ratio of the total for fuel, ammunition, and repair parts to the active other equipment cost.

**Table B.18**  
**ARMY OPERATING AND SUPPORT COSTS: MECHANIZED**  
**INFANTRY BATTALION, ALOs 1 AND 2**  
**(\$ FY 1983 million)**

	ALO 1		ALO 2	
	USA	ARNG	USA	ARNG
<b>Personnel</b>				
<b>Pay and allowances</b>				
Officer	1.39	0.28	1.39	0.28
Enlisted	12.69	2.23	10.37	1.89
Total	14.08	2.51	11.76	2.17
<b>Other personnel costs</b>				
Officer	0.33	0.02	0.33	0.02
Enlisted	5.39	0.37	4.41	0.31
Total	5.73	0.39	4.74	0.32
<b>Replacement training costs</b>				
Officer	.07	0.06	0.07	0.06
Enlisted	2.06	1.49	1.68	1.22
Total	2.13	1.55	1.75	1.28
<b>Total personnel costs</b>	<b>21.93</b>	<b>4.45</b>	<b>18.25</b>	<b>3.78</b>
<b>Equipment</b>				
<b>Fuel</b>	<b>0.08</b>	<b>0.11</b>	<b>0.06</b>	<b>0.04</b>
<b>Training ammunition</b>	<b>1.06</b>	<b>0.19</b>	<b>0.97</b>	<b>0.21</b>
<b>Repair parts</b>	<b>0.54</b>	<b>0.67</b>	<b>0.66</b>	<b>0.20</b>
<b>Other</b>	<b>0.46</b>	<b>0.27</b>	<b>0.19</b>	<b>0.05</b>
<b>Total equipment costs</b>	<b>2.15</b>	<b>1.24</b>	<b>1.88</b>	<b>0.50</b>
<b>Total unit costs</b>	<b>24.08</b>	<b>5.69</b>	<b>20.13</b>	<b>4.27</b>

**Table B.19**  
**OPERATING AND SUPPORT COSTS: ARMY COMBAT**  
**ENGINEER BATTALION, ALO 1**  
**(\$ FY 1983 million)**

	USA	ARNG
<b>Personnel</b>		
Pay and allowances		
Officer	1.42	0.22
Enlisted	12.19	2.20
Total	13.61	2.42
Other personnel costs		
Officer	0.34	0.02
Enlisted	5.18	0.36
Total	5.52	0.38
Replacement training costs		
Officer	0.08	0.07
Enlisted	2.16	1.56
Total	2.24	1.63
Total personnel costs	21.37	4.43
<b>Equipment</b>		
Fuel	0.08	0.08
Training ammunition	0.07	0.04
Repair parts	0.54	0.73
Other	0.36	0.44
Total equipment costs	1.05	1.29
<b>Total unit costs</b>	<b>22.42</b>	<b>5.72</b>

**Table B.20**  
**OPERATING AND SUPPORT COSTS: ARMY TANK**  
**BATTALION, ALOs 1 AND 2**  
(\$ FY 1983 million)

	ALO 1		ALO 2	
	USA	ARNG	USA	ARNG
<b>Personnel</b>				
Pay and allowances				
Officer	1.22	0.25	1.16	0.24
Enlisted	7.56	1.41	7.05	1.34
Total	8.78	1.66	8.21	1.58
Other personnel costs				
Officer	0.29	0.02	0.28	0.02
Enlisted	3.22	0.22	3.00	0.21
Total	3.51	0.24	3.28	0.23
Replacement training costs				
Officer	0.11	0.06	0.10	0.06
Enlisted	1.74	1.30	1.62	1.19
Total	1.85	1.36	1.72	1.25
Total personnel costs	14.14	3.26	13.21	3.06
<b>Equipment</b>				
Fuel	0.12	0.09	0.14	0.04
Training ammunition	2.31	0.71	1.62	0.38
Repair parts	0.82	0.72	1.19	0.23
Other	0.41	0.19	0.18	0.04
Total equipment costs	3.66	1.71	3.13	0.69
Total unit costs	17.80	4.96	16.33	3.75

Table B.21

**OPERATING AND SUPPORT COSTS: ARMY FIELD ARTILLERY  
BATTALION, ALOs 1 AND 2  
(\$ FY 1983 million)**

	ALO 1		ALO 2	
	USA	ARNG	USA	ARNG
<b>Personnel</b>				
Pay and allowances				
Officer	0.96	0.21	0.96	0.21
Enlisted	7.32	1.61	6.83	1.54
Total	8.28	1.82	7.79	1.75
Other personnel costs				
Officer	0.23	0.01	0.23	0.01
Enlisted	3.11	0.22	2.90	0.21
Total	3.34	0.23	3.13	0.22
Replacement training costs				
Officer	0.08	0.05	0.08	0.05
Enlisted	1.14	0.82	1.07	0.77
Total	1.22	0.87	1.15	0.81
Total personnel costs	12.84	2.91	12.07	2.78
<b>Equipment</b>				
Fuel	0.06	0.08	0.06	0.01
Training ammunition	1.29	0.45	1.57	0.31
Repair parts	0.53	0.75	0.44	0.15
Other	0.46	0.31	0.13	0.03
Total equipment costs	2.34	1.60	2.19	0.50
Total unit costs	15.18	4.53	14.26	3.29

## ARMY GLOSSARY

<b>ADT</b>	active duty training
<b>AFPCH</b>	Army Force Planning Cost Handbook
<b>AGR</b>	active duty guard/reserve (full-time)
<b>ALO</b>	authorized level of organization
<b>AMMO</b>	ammunition
<b>ASL</b>	Army stock list
<b>AT</b>	Army technician
<b>BOS</b>	base operating support
<b>CONUS</b>	continental United States
<b>DAAR</b>	Office of the Chief of the Army Reserve (OCAR)
<b>DAMO</b>	Deputy Chief of Staff for Operations and Plans
<b>DS</b>	direct support
<b>ENG</b>	engineer
<b>FA</b>	field artillery
<b>FCIS</b>	force cost information system
<b>FORSCOM</b>	Forces Command
<b>GS</b>	general support
<b>IDT</b>	inactive duty training
<b>MAJCOM</b>	Major Command (also MACOM in U.S. Army usage)
<b>MATES</b>	mobilization, training, and equipment site
<b>MOGAS</b>	motor gasoline
<b>MOS</b>	military occupational specialty
<b>MPA</b>	military personnel appropriation
<b>NGB</b>	National Guard Bureau
<b>NPS</b>	nonprior service
<b>OMA</b>	operations and maintenance account
<b>O&amp;S</b>	operations and support
<b>PCS</b>	permanent change of station
<b>PEMA</b>	procurement appropriation
<b>PLL</b>	prescribed load list
<b>POL</b>	petroleum, oil, and lubricants
<b>TAMIS</b>	Training Ammunition Management Information System
<b>TO&amp;E</b>	table of organization and equipment
<b>TRADOC</b>	Training and Doctrine Command
<b>TUFMIS</b>	Tactical Unit Financial Management Information System

## REFERENCES

- B.1. Department of the Army, *Table of Organization and Equipment*.
- B.2. Department of the Army, *Justification of Estimates for FY 1984, Military Personnel, Army*, submitted to the Congress February 1983.
- B.3. Department of the Army, *Justification of Estimates for FY 1984, Reserve Personnel, Army*, submitted to the Congress February 1983.
- B.4. Department of the Army, *Justification of Estimates for FY 1984, National Guard Personnel, Army*, submitted to the Congress February 1983.
- B.5. Department of the Army, *Justification of Estimates for FY 1984, Operation and Maintenance, Army*, submitted to the Congress February 1983.
- B.6. Department of the Army, *Justification of Estimates for FY 1984, Operation and Maintenance, Army Reserve*, submitted to the Congress February 1983.
- B.7. Department of the Army, *Justification of Estimates for FY 1984, Operation and Maintenance, Army National Guard*, submitted to the Congress February 1983.
- B.8. Department of the Army, *Force Planning Cost Handbook (AFPCH)*, Directorate of Cost Analysis, Office of the Comptroller of the Army, Washington, D.C., November 1982.

## Appendix C

### NAVY COST FACTOR DERIVATION

The development of cost factors for estimating the annual O&S costs of the Navy active (USN) and reserve (USNR) units, including the appropriate data sources, is described in this appendix. The factors are specifically developed for carrier-based F-4S (12 PAA) aircraft squadrons and FF1052-class frigates.

This appendix shows the derivation of cost factors for personnel and equipment, the cost-estimating equations, and the case study results. All costs are given in FY 1983 dollars unless otherwise specified. References and a glossary appear at the end of Appendix C.

Frigates of the FF1052 class differ in equipment, reflecting specific modifications; the number of personnel varies slightly, depending on the equipment. We compared the personnel levels of two similarly equipped ships of the Pacific Fleet with home ports in CONUS: the *Hepburn* (active) and the *Gray* (reserve).

The only two active F-4S squadrons are both based on the *Midway*. We compared the average personnel levels for these two active squadrons with the average of two reserve units: VF201 squadron based at Dallas, Texas, and VF302 squadron based at the Miramar Naval Air Station, California.

#### **PERSONNEL COST FACTOR SUMMARY**

The average officer and enlisted personnel factors are shown in Table C.1. Table C.2 shows the values for the personnel in the air squadron and frigate case studies. These values differ from those in Table C.1 only with regard to the inclusion of additional drill days for the case study units. The replacement training factors are shown in Table C.3.

#### **PERSONNEL STRENGTH**

The unit personnel strength factors include the required levels and composition of full-time and part-time officers and enlisted plus those of civilians working for the unit. These values were obtained from the

**Table C.1**  
**NAVY PERSONNEL COST FACTOR SUMMARY**  
**(\\$ FY 1983)**

Cost Factors	Flight-rated	Sea-rated	Non-rated
<b>Pay and allowances<sup>a</sup></b>			
Officer			
Full-time active	39,212	37,879	35,624
Reserve/augmentee	6,311	5,593	5,501
TAR	43,757	43,757	43,757
Enlisted			
Full-time active	17,001	17,392	15,722
Reserve/augmentee	2,470	2,329	2,263
TAR	17,924	17,924	17,924
Civilian	22,698	22,698	22,698
<b>Other personnel costs</b>			
Officer			
Full-time active	6,890	6,890	6,890
Reserve/augmentee	2,186	2,186	2,186
TAR	3,001	3,001	3,001
Enlisted			
Full-time active	5,671	5,671	5,671
Reserve/augmentee	1,871	1,871	1,871
TAR	2,500	2,500	2,500
<b>Other reserve training</b>			
Officer	354	354	354
Enlisted	71	71	71

<sup>a</sup>The cost factors include no additional drill periods for reservists.

appropriate *Manpower Authorization Form* (1000/2) [C.1] for the FF1052 frigates and F-4S squadrons previously mentioned.

The unit personnel include equipment operators, organizational-level maintenance personnel, and unit administrative and overhead personnel. For the aircraft squadrons, the manpower authorizations also include the variable support personnel (supply, laundry, food, etc.) required to augment the aircraft carrier or shore station support functions plus a complement of intermediate maintenance personnel assigned to temporary duty (TAD) with the centralized carrier or shore

Table C.2  
NAVY PAY AND ALLOWANCE COST FACTORS  
FOR F-4S AND FF1052 PERSONNEL  
(\$ FY 1983)

	F-4S <sup>a</sup>		FF1052
	Flight-rated	Non-rated	Sea-rated
<b>Officer</b>			
Full-time active	41,467	37,879	37,879
Part-time reserve	13,293	6,585	8,072
TAR	43,757	43,757	43,757
Augmentee	10,422	5,593	5,593
<b>Enlisted</b>			
Full-time active	18,671	17,392	17,392
Part-time reserves	2,536	2,709	3,279
TAR	17,924	17,924	17,924
Augmentee	2,536	2,329	2,329

<sup>a</sup>Active rated personnel receive both flight and sea pay; active nonrated personnel receive sea pay.

station Aircraft Intermediate Maintenance Department (AIMD). For the frigate, the manpower authorizations also include the variable support personnel; however, they do not include the intermediate level personnel needed to maintain the ship.

Each active unit has a selected reserve augmentation identified as a mobilization requirement on the manpower authorization form. These reserve augmentees usually train with their unit (or a similar active unit) during some of their annual drill periods and are included accordingly in the active unit costs.

Reserve units require a large complement of full-time personnel to provide the continuing equipment maintenance and administrative support needed for peacetime operations. The full-time personnel are

Table C.3  
NAVY REPLACEMENT TRAINING COST FACTOR SUMMARY  
(\$ FY 1983)

	USN	USNR
<b>F-4S</b>		
Pilot	194,910	0
Flight officer	56,940	0
Non-flight officer	5,850	3,120
Non-flight enlisted	3,502	510
<b>FF1052</b>		
Officer	6,750	3,600
Enlisted	3,562	519

NOTE: The numbers represent (training cost/  
student) \* (turnover rate).

either personnel from training and administration of reserves (TARs) or USN personnel assigned to the reserve unit.

On the manpower authorization forms, the full-time personnel are identified in the Planned Authorization columns, where TARs are identified with a special code (usually E or T). The part-time reservists are listed in the Mobilization Requirements columns.

The personnel levels used to generate the operating and support costs for the active and reserve FF1052 frigates and the F-4S aircraft squadrons are displayed in Table C.4.

#### PER CAPITA COST FACTORS

The unit personnel levels are combined with various per capita factors to estimate the annual personnel-related costs. Separate factors are developed for pay and allowances, replacement acquisition and training, and other personnel costs, such as travel and medical. Separate active and reserve factors were developed for officers, enlisted, and civilians with subcategories for flight-rated, non-flight-rated, sea-rated, non-sea-rated, and TAR personnel.

In general, the personnel factors were developed by dividing the costs displayed in the active and reserve personnel Budget

Table C.4  
NAVY FF1052 AND F-4S PERSONNEL STRENGTH

	FF1052		F-4S	
	USN	USNR	USN	USNR
<b>Officers</b>				
<b>Active (USN)</b>				
Pilots	0	0	13	0
Other aircrew	0	0	13	0
Supervisory rated	0	0	2	0
Non-flight	17	6	3	0
<b>Part-time reserve</b>				
Pilots	0	0	3	14
Other aircrew	0	0	3	13
Supervisory rated	0	0	0	2
Non-flight	0	8	0	4
<b>Full-time reserve (TARs)</b>				
Pilots	0	0	0	2
Other aircrew	0	0	0	3
Supervisory rated	0	0	0	0
Non-flight	0	3	0	0
Total officers	17	17	37	38
<b>Enlisted</b>				
<b>Active (USN)</b>				
Flight-rated	0	0	0	0
Non-flight	264	74	235	3
<b>Part-time reserve</b>				
Flight-rated	0	0	0	0
Non-flight	32	138	1	138
<b>Full-time reserve (TARs)</b>				
Flight-rated	0	0	0	0
Non-flight	0	85	0	96
Total enlisted	296	297	236	237

SOURCE: [1].

Justifications [C.2, C.4] by the appropriate average personnel strengths for the specific categories. The strength factors used for the computations are shown in Table C.5.

### Active Pay and Allowances

An active unit has both active personnel and reserve augmentees. For the active Navy, an average officer and enlisted pay factor was derived by dividing the total pay for officers and enlisted (as shown in Ref. C.2, less flight and sea pay) by the average officer and enlisted strength. The cost categories included in the pay and allowance factor are shown in Table C.6.

Some personnel receive additional flight pay and/or sea pay. From the Budget Justification, the total budget for flight pay<sup>1</sup> and sea pay was divided by the appropriate personnel strengths to arrive at an average officer and enlisted increment for flight and sea pay. These calculations are shown in Table C.7.

Table C.5

NAVY AVERAGE PERSONNEL STRENGTH, FY 1983

	USN	USNR
<b>Pay group A</b>		
Officer	67,216	18,500
Enlisted	476,749	73,990
<b>Flight-rated</b>		
Officer	22,444	5,180
Enlisted	8,133	1,406
<b>Sea-rated</b>		
Officer	7,914	Unknown
Enlisted	107,943	Unknown
<b>Pay group D</b>		
Officer	0	180
Enlisted	0	170
<b>Civilian</b>	124,421	Unknown
<b>TAR</b>		
Officer	0	1,159
Enlisted	0	10,341

SOURCES: [2], pp. 1-5; [4], pp. 9, 67, 68;  
NOP-09R3.

<sup>1</sup>The budget category for flight pay includes Aviation Career Continuation Pay, which represents reenlistment bonuses of up to 4 months of basic pay for each additional year of active duty beyond the expiration of obligated service. This additional incentive pay for active rated officers results in a significant differential between active and reserve flight pay per day.

**Table C.6**  
**USN PERSONNEL PAY AND ALLOWANCE FACTORS**  
**(\$ FY 1983)**

	Officer	Enlisted
<b>Pay and allowances (\$000)</b>		
Basic pay	1,730,659	5,004,809
Quarters	244,231	645,448
Housing	76,792	214,774
Subsistence	79,183	712,134
Incentive (less flight pay)	18,845	64,889
Special (less sea pay)	84,482	262,884
Allowances	22,547	183,756
Separation	26,126	67,694
Social Security	111,349	335,322
Other	273	3,765
Total (\$000)	2,394,487	7,495,475
Strength (000)	67,216	476,749
Pay per capita (\$)	35,624	15,722

SOURCE: [2], pp. 1-9 to 1-11.

**Table C.7**  
**USN FLIGHT- AND SEA-PAY FACTORS**  
**(\$ FY 1983)**

	Officer	Enlisted
<b>Total flight pay (\$000)</b>	80,530	10,399
Number of flight-rated	22,444	8,133
Cost per capita (\$)	3,588	1,279
<b>Total sea pay (\$000)</b>	17,849	180,228
Number of sea-rated	7,914	107,943
Cost per capita	2,255	1,670

SOURCE: [2], pp. 1-9 to 1-11.

Finally, pay and allowance cost factors for various personnel categories were developed by adding these increments to the average officer and enlisted pay. The final pay and allowance factors for active personnel are shown in Table C.8.

Pay for civilian personnel in the active Navy is contained in the active O&M Budget Justification ([C.3], Vol. I, p. 5). The average civilian compensation is \$22,698.

#### **Reserve Pay and Allowances**

**Reserve Personnel.** The Budget Justifications do not break down flight and sea pay for reserve personnel, but the USNR Personnel Resources Branch (NOP-09R32) provided an average cost per day, shown in Table C.9. The average reservist (including active unit reserve augmentees) drills 14 active duty training (ACDUTRA) days and 48 inactive duty training (IDT) periods (2 drills per day). Thus, a general pay factor can be derived by multiplying cost per day times participation rate times number of drill days per year, as shown in

Table C.8

**USN TOTAL PAY FACTORS PER CAPITA  
(\$ FY 1983)**

	Officer	Enlisted
<b>Flight- and sea-rated</b>		
Pay and allowances	35,624	15,722
Flight pay	3,588	1,279
Sea pay	2,255	1,670
Total	41,467	18,671
<b>Flight-rated</b>		
Pay and allowances	35,624	15,722
Flight pay	3,588	1,279
Total	39,212	17,001
<b>Sea-rated</b>		
Pay and allowances	35,624	15,722
Sea pay	2,255	1,670
Total	37,879	17,392
<b>Nonrated</b>	35,624	15,722

**Table C.9**  
**USNR AVERAGE DAILY PAY FACTORS**  
**(\$ FY 1983)**

	Cost per Day (\$)	Partici- pation Rate	Number of Drills	Cost per Year (\$)
<b>Pay and allowances</b>				
Officer				
ACDUTRA	109.02	.99	14	1511.02
IDT	83.47	.99	48	3966.72
Total (rounded)				5478.00
Enlisted				
ACDUTRA	49.01	.81	14	555.77
IDT	35.59	.89	48	1520.40
Total (rounded)				2076.00
<b>Flight pay</b>				
Officer				
ACDUTRA	13.19	.99	14	182.81
IDT	13.19	.99	48	626.79
Total (rounded)				810.00
Enlisted				
ACDUTRA	3.83	.81	14	43.43
IDT	3.83	.89	48	163.62
Total (rounded)				207.00
<b>Sea pay</b>				
Officer				
ACDUTRA	6.67	.99	14	92.45
IDT	0	.99	48	0
Total (rounded)				92.00
Enlisted				
ACDUTRA	5.83	.81	14	66.18
IDT	0	.89	48	0
Total (rounded)				66.00

SOURCE: Data on costs per day and participation rates were provided by the Office of the Chief of Naval Operations, Reserve Personnel Resources Branch (NOP-09R32).

Table C.9. For rated personnel, flight pay is accrued for each drill day (inactive or active). Sea pay is only earned for ACDUTRA.

In addition to these pay and allowances, a per capita figure was derived from the Budget Justifications for subsistence and clothing allowances (see Table C.10). Table C.11 shows the average pay per

**Table C.10**  
**USNR OTHER PAY AND ALLOWANCE FACTORS**  
**(\$ FY 1983)**

	Officer	Enlisted
Clothing (\$000)	431	8,518
Subsistence (\$000)	0	5,294
Total (\$000)	431	13,812
Total per capita (\$)	23	187

SOURCE: [4], pp. 32, 33.

**Table C.11**  
**USNR PAY AND ALLOWANCE FACTORS WITHOUT**  
**ADDITIONAL DRILL DAYS**  
**(\$ FY 1983)**

	Officer	Enlisted
Nonrated		
Pay	5478	2076
Other	23	187
Total	5501	2263
Flight-rated		
Pay and allowances	5501	2263
Flight pay	810	207
Total	6311	2470
Sea-rated		
Pay and allowances	5501	2263
Sea pay	92	66
Total	5593	2329
Flight- and sea-rated		
Pay and allowances	5501	2263
Flight pay	810	207
Sea pay	92	66
Total	6403	2536

year for the personnel cost categories, assuming no additional drill days.

In addition to the normal 14 active duty and 48 inactive duty drill periods, reserve units drill additional inactive duty periods to ensure mission readiness. The number of additional drill periods varies by type of unit. Personnel receive full pay and allowances for these additional drills. The specific additional drill days programmed to be performed by the FF1052s and the F-4 squadrons and the resulting pay for these drill periods are displayed in Table C.12.

Active unit reserve augmentees are also programmed for additional drill days, as shown. The extra drills are costed at the inactive duty rate. Since sea duty pay is not accrued for inactive duty drills, no sea pay additive is included in the calculation of annual cost for additional drills. The resulting costs (Table C.12) are then added to the pay

**Table C.12**  
**USNR COST FACTORS FOR ADDITIONAL DRILL DAYS**  
**(\\$ FY 1983)**

	Cost per Day (\$)	Partici- pation Rate	Added Drill Days	Cost per Year (\$)
<b>FF1052 frigate reservists</b>				
Officer (base pay)	83.47	.99	30	2479
Enlisted (base pay)	35.59	.89	30	950
<b>F-4S reservists</b>				
Flight-rated officer				
Base pay	83.47	.99	72	5950
Flight pay	13.19	.99	72	940
Non-flight officer pay	83.47	.99	12	992
Non-flight enlisted pay	35.59	.89	12	380
<b>F-4S active augmentees</b>				
Flight-rated officer				
Base pay	83.47	.99	42	3471
Flight pay	13.19	.99	42	548

SOURCE: [6].

without additional drill days in Table C.11, above, to arrive at the final reserve cost per person for pay and allowances shown in Table C.13.<sup>2</sup>

TARs. The cost factors for TARs, developed from Ref. C.4, include all pay and allowances. The total budget category for TAR pay and allowances was divided by the total number of TARs to arrive at an

**Table C.13**  
**USNR TOTAL PAY AND ALLOWANCE FACTORS**  
**(\$ FY 1983)**

Type of Personnel	Officers	Enlisted
<b>FF1052 frigate</b>		
Reservist		
No additional drills	5,593	2,329
Additional drills	2,479	950
Total	8,072	3,279
Augmentee		
No additional drills	5,593	2,329
Additional drills	0	0
Total	5,593	2,329
<b>F-4S</b>		
Flight-rated reservist		
No additional drills	6,403	2,536
Additional drills	6,890	0
Total	13,293	2,536
Non-flight-rated reservist		
No additional drills	5,593	2,329
Additional drills	992	380
Total	6,585	2,709
Flight-rated augmentee		
No additional drills	6,403	2,536
Additional drills	4,019	0
Total	10,422	2,536
Non-flight-rated augmentee		
No additional drills	5,593	2,329
Additional drills	0	0
Total	5,593	2,329

<sup>2</sup>The Budget Justifications and the Navy instruction give no indication of historic participation in these additional drills by type of unit. They have been costed, therefore, at the same participation rate as inactive duty drills. Discussions with officers in the Office of Naval Operations (OP-09R) indicate that the participation rate may actually be closer to 60 percent. Data now being gathered for the first time will allow a more accurate costing of these additional drill days in the future.

average per officer or enlisted cost. No flight- or sea-rated breakdown was provided; the additional pay for this duty is averaged across all TAR personnel. The results are shown in Table C.14.

**Civilians.** Since the reserve force budget does not contain separate civilian costs, the active factor (\$22,698) is used for civilians associated with reserve units. No civilian personnel are associated with the reserve ship or aircraft case studies.

Table C.14  
USNR TAR PAY AND ALLOWANCE FACTORS  
(\\$ FY 1983)

	Officers	Enlisted
Pay and allowances (\$000)	50,714	185,351
Strength	1,159	10,341
Cost per capita (\$)	43,757	17,924

SOURCE: [4], pp. 67, 68.

#### Other Personnel-Related Costs

**Active Force General Factor.** For active personnel, other general personnel costs include only that for permanent change of station (PCS). All other costs have been included in pay and allowances. The PCS costs, taken from the Budget Justification ([C.2], pp. 1-11), are derived in Table C.15 by dividing total budget dollars by average strength.

Table C.15  
USN OTHER PERSONNEL COST FACTORS  
(\\$ FY 1983)

	Officers	Enlisted
Permanent change of station (\$000)	138,936	404,096
Strength	67,216	476,749
Cost per capita (\$)	2,067	848

SOURCE: [2], p. 1-11.

**Reserve Force General Factor.** For the reserves, this category includes ACDUTRA travel, bonuses, IDT travel, death gratuities, and hospitalization. It is derived from the Budget Justification [C.3] in a manner similar to the active factor. Separate travel costs are derived for reservists and TARs, but a single number with an officer/enlisted split for the other costs is applied to reservists and TARs. Thus, the divisor for costs other than travel is the sum of Pay Group A and TARS. The derivation and results are shown in Table C.16.

**Active BOS Nonpay Factor.** The cost of the marginal increase in support associated with a unit locating on a base should be attributed to the unit. The support takes the form of O&M funds, including some civilian employment.<sup>3</sup>

For the USN, the O&M Budget Justification ([C.3], Vol. 1), contains a summary of all costs, including those related to base operations. Of

Table C.16

USNR OTHER GENERAL PERSONNEL COST FACTORS  
(\$ FY 1983)

	USNR (excluding TAR)		TAR	
	Officer	Enlisted	Officer	Enlisted
Travel (\$000)	14,367	44,939	1,845	10,858
Strength	18,500	73,990	1,159	10,341
Cost per capita (\$)	777	421	1,592	1,050
Death gratuities and hospitalization (\$000)	277	622	277	622
Strength	19,839	84,501	19,839	84,501
Cost per capita (\$)	14	7	14	7
Bonuses (\$000)	0	4,098	0	4,098
Strength	19,839	84,501	19,839	84,501
Cost per capita (\$)	0	48	0	48
Total general cost per capita (\$)	791	476	1,606	1,105

SOURCE: [4], pp. 34, 67, 73, and 74.

<sup>3</sup>Support costs do not include military support personnel pay and allowances. The marginal military support personnel requirements of a unit are included in unit personnel figures. Therefore, support costs include expenses such as utilities, supplies, rentals, and the pay of civilian support personnel.

the many base operations categories, some are related to overhead functions, such as administration, or are not applicable to the case study units. These base operating costs are not included. Base operation budget costs related to the support of general purpose forces are shown in Table C.17. These costs include real property maintenance (RPM) and base operations ([C.3], p. 12). The total budget dollars are divided by the general purpose force average personnel strength (military plus civilian) to derive a per capita BOS nonpay factor.

The total costs of communications, medical facilities, and morale support are included in the budget under Program 3—Intelligence and Communications and Program 8—Training and Medical, rather than under general purpose forces. Table C.17 also shows the relevant budget costs associated with this support. This total is divided by the active force strength (military and civilian) to arrive at a per capita factor. The total active BOS nonpay factor = \$863 + \$3960 = \$4823.

**Reserve BOS Nonpay Factor.** A similar method is used to derive USNR base operating support costs, which are shown in Table C.18.

Table C.17  
USN BOS NONPAY FACTORS  
(\$ FY 1983)

BOS and RPM costs (\$000) <sup>a</sup>	1,346,498
Strength	340,043
Cost per capita (\$)	3,960
Other costs (\$000)	
Medical care in regional facilities	121,416
Station hospitals and clinics	139,525
Dental care	12,186
Care in non-Defense facilities	50,803
Other personnel activities	75,434
Leased communications	177,454
Total	576,818
Strength	668,386
Other cost per capita (\$)	863
Total BOS nonpay costs per capita (\$)	4,823

SOURCES: [3], Vol. 1, pp. 12-17; strength data are taken from [3], Vol. 3, pp. 1-2-1 to 1-2-82 as the average strength of total reported manpower of each general purpose force subcategory.

<sup>a</sup> Based on general purpose forces in CONUS.

Table C.18  
USNR BOS NONPAY FACTORS  
(\$ FY 1983)

Base operations (\$000)	145,605
Strength	104,340
Cost per capita (\$)	1,395

SOURCE: [5], p. 2.

The divisor of the budget dollars is average force strength of pay groups A and D, TARs, and civilians. The reserve base operations category includes medical support, morale, and communications.

#### Replacement Acquisition and Training Costs

This category of personnel cost covers the acquisition and training of personnel to replace those who left the unit during the year. The current cost factors for acquisition and training include the costs of recruitment, basic recruit training, and initial skill training (termed A School). Because data were not available, the cost of the formal school training beyond A School that may be required for certain skills (termed C School) is not included in the cost factors. Included in the cost factors are the pay and allowances of recruiters, trainers, and students; travel to and from training installations; recruitment advertising; the books and other materials required for classroom instruction; and any equipment operating cost involved in the training programs. The training cost factors are based on the number of graduates and include the effects of any personnel attrition during training.

**Enlisted Personnel.** Separate recruiting, recruit training, and A School training cost factors for various enlisted ratings have been developed by the Center for Naval Analyses (CNA) [C.7]. These cost factors, updated to FY 1983 dollars, are used to generate the acquisition and training cost of replacement personnel.

Although values are available for a wide range of ratings, the separate costs have been compressed into a single average factor across all ratings. The costs for recruiting and recruit training are very similar across the various ratings analyzed by CNA; therefore, the average factors differ little from the separate rating factors. Training costs for A School vary substantially, however, with the cost for the most expensive rating being four times the cost of the least expensive rating.

Because of this wide variation in A School costs, we developed a weighted average. This weighted average multiplies the A School cost for each rating by the number of personnel with that rating (based on the active unit manpower authorizations from Ref. C.1) and then divides by the number of enlisted personnel. The resulting cost factors are presented in Table C.19.

The enlisted factors are for nonrated (non-aircrew) personnel. Since there are no enlisted aircrew in F-4S squadrons, the costs in Table C.19 are the only enlisted factors needed in the case study analysis. However, other types of aircraft (for example, P-3s) may carry enlisted aircrew members. For rated enlisted personnel, separate factors would be required for A school and flight training.

**Officers.** We found no readily available cost data for officers comparable to the CNA data for enlisted acquisition and initial training cost. Therefore, we based the replacement training costs for officers on information from a number of Navy organizations.

Table C.20 shows the pipeline projections for different officer communities for FY 1985. We obtained these values from the Officer Program Implementation Branch of the DCNO/Chief of Naval Personnel (NOP-130). Pipeline proportions typically change from year to year to reflect differences in retention and recruiting. The cost per graduate

Table C.19

ACQUISITION AND TRAINING COSTS FOR  
NAVY ENLISTED PERSONNEL  
(\$ FY 1983)

	FF-1052	F-4S
Recruiting	6,500	6,500
Recruit training	3,500	3,500
A School training	7,900	7,600
Total	17,900	17,600

SOURCE: [7]; the costs for quality type 2 (high school graduate, category III-IV) were updated to FY 1983 dollars using a factor of 1.03.

NOTE: The recruiting and recruit training factors are averages across all ratings. The A School training factors are weighted averages based on the active unit's manpower authorization form.

**Table C.20**  
**NAVY OFFICER ACQUISITION PROJECTIONS AND COSTS**

Training Source	Percentage of Officers from Each Training Source				Cost per Graduate (\$)
	Pilot	Naval Flight	Surface Ship	Other Aviation	
Naval Academy	18	13	18	25	120,000
ROTC <sup>a</sup>	33	23	32	35	30,000
Aviation officer candidate school	49	64	--	40	15,000
Officer candidate school	--	--	50	--	11,000

SOURCE: Percentages were provided by NOP-130, costs by NOP-114.

<sup>a</sup>Average of 2-year and 4-year programs of Reserve Officer Training Corps (ROTC).

for each of the officer pipelines was provided by the Education Plans and Policy Branch of the DCNO for Naval Personnel (NOP-114).

The cost associated with the initial training varies by officer community. Initial estimates of the training cost for officers other than aircrew members was provided by the Military Personnel Management Branch of the DCNO for Naval Personnel (NOP-132). The cost of undergraduate pilot training (UPT) and the basic and intermediate courses for naval flight officers (NFOs) was provided by the Aviation Manpower and Training Division of the DCNO for Air Warfare (NOP-59). These costs, along with the weighted acquisition costs from Table C.20, are shown in Table C.21.

#### **Replacement Acquisition and Training Turnover**

For active units, the turnover factor measures personnel turnover; for reserve units, the factor measures turnover that is filled with nonprior-service personnel (all reserve aircrew members have prior service).

An initial estimate of personnel turnover is based on the losses experienced by the active and reserve forces. Losses are examined

**Table C.21**  
**NAVY OFFICER ACQUISITION AND TRAINING COSTS**  
**(\$ FY 1983)**

Type of Officer	Acquisition	Training <sup>a</sup>	Total <sup>b</sup>
Pilot	38,850	850,000	890,000
Naval flight (NFO)	32,100	226,000	260,000
Other aviation	36,700	28,000	65,000
Surface ship	46,500	28,000	75,000

<sup>a</sup>For pilots and NFOs, cost includes UPT, basic and intermediate courses, and a share of Fleet Readiness Squadron operating costs.

<sup>b</sup>Rounded to nearest \$5000.

instead of gains to overcome any influences of planned growth in personnel strength. For the active force, the losses are divided by average strength to estimate a turnover percentage. For reserve units, the above factor is modified by the percentage of gains with prior service, thereby assuming that some portion of losses will be filled by already trained individuals.

Separate retention factors are derived for pilots and other aircrew members. As mentioned, all reserve rated personnel have prior service; therefore, the turnover factor for reserve rated officers is 0. For active rated officers, the current projection of F-4 graduates from the UPT pipeline (7) is divided by the number of pilots in the two active F-4 units (32) to estimate the turnover percentage. The various calculations and resulting factors are summarized in Table C.22.

#### Other Reserve Training Costs

In addition to the drill periods covered under the pay and allowances cost factor, reserve personnel often spend additional days in training for other types of activities. These include the refresher and proficiency training of personnel with prior service, career development classes, and other events and activities that prepare the units for their wartime missions. The costs of these additional training days are included under "other" training costs. The categories that are included and the resulting cost factors are displayed in Table C.23.

**Table C.22**  
**NAVY PERSONNEL TURNOVER FACTORS**

Personnel Category	USN	USNR
<b>Enlisted</b>		
Losses <sup>a</sup>	94,667	26,255
% without prior service	100	8.2
Strength	476,749	74,160
Turnover rate	.199	.029
<b>Nonrated officers</b>		
Losses <sup>a</sup>	6,051	5,088
% without prior service	100	17.5
Strength	67,216	18,650
Turnover rate	.090	.048
<b>Rated officers</b>		
UPT graduates	7	0
Fleet pilots	32	--
Turnover rate	.219	0

SOURCES: For enlisted personnel and nonrated officers--[2], pp. 1-7, 1-8; [4], pp. 11, 12. For UPT graduates--DCNO (Air Warfare), Tactical Air Training Branch, NOP-593.

<sup>a</sup>With reinlistments subtracted from losses.

**Table C.23**  
**USNR OTHER TRAINING COST FACTOR**  
(\$ FY 1983)

	Enlisted    Officer	
<b>School (\$000)</b>		
Career development	481	1,027
Refresher/proficiency	1,378	1,261
<b>Special (\$000)</b>		
Exercises	737	1,793
Service mission	1,814	929
Operational training	179	1,544
ACDUTRA	685	0
<b>Total (\$000)</b>	<b>5,274</b>	<b>6,554</b>
<b>Strength</b>	<b>73,990</b>	<b>18,500</b>
<b>Cost per capita (\$)</b>	<b>71</b>	<b>354</b>

SOURCE: [4], p. 14.

### EQUIPMENT OPERATING COST FACTORS

The second major component of a unit's annual operating and support cost is the expenditures for operating and maintaining the unit's equipment. Ideally, these costs are estimated using a programmed operating tempo multiplied by cost per operating unit plus fixed costs. The equipment cost factors derived for the Navy case studies are shown in Tables C.24 and C.25. Their derivation follows.

Three major Navy data sources enable us to track equipment operating cost: the *Visibility and Management of Operating and Support Costs* (VAMOSC) [C.8, C.14], the *Resource Allocation Document* (RAD) [C.9], and the *Navy Program Factors Manual* (PFM) [C.10]. Each has advantages and disadvantages as a data source.

Reserve equipment operating cost data and models for building active and reserve costs from the bottom up were not readily available, especially from a single source. Therefore, we had to piece together costs from different sources, using information obtained in conversations with various offices to derive general relationships. Each cost

Table C.24  
NAVY FF1052 EQUIPMENT COST FACTORS  
(\$ FY 1983)

	USN	USNR
Steaming days		
Underway	159	59
Hours/day	19	19
Cost/steaming hour (\$)	731	770
Not underway	70	50
Cost/steaming hour (\$)	242	242
Days in port	183	279
Cost/days in port (\$)	1,523	1,523
Full-time manning equivalents	288	190
Cost/full-time manning (\$)	943	943
IMA man-years	29.8	155.5
Cost/IMA man-year (\$)	15,374	15,374
Repair cost/ship (\$)	661,913	661,913
Overhaul cost/ship (\$)	4,766,087	4,766,087
Ordnance cost/ship (\$)	413,283	413,283

**Table C.25**  
**NAVY F-4S AIRCRAFT EQUIPMENT COST FACTORS**  
**(\\$ FY 1983)**

	USN	USNR
Flying hours/aircraft/year	302	219
Cost/squadron/year (\$) for		
Training ordnance	1,246,035	498,414
Costs/aircraft/year (\$) for		
Modifications	185,250	185,250
Depot, SDLM	135,300	135,300
Costs/flying hour (\$) for		
POL	1,634	1,360
Maintenance material	769	553
Replenishment spares	50	50
Depot, engine and components	662	662

element is described below with its cost factor derivation. The VAMOSC data were usually used to derive cost factors for both active and reserve units because these data have some historic validity and were the most complete.<sup>4</sup> The major exception is for operating tempo and fuel costs.

#### Ship Equipment-Related Costs

Like most equipment costs, ship operation and maintenance costs have both a fixed and a variable portion. For the Navy, the fixed portion represents the majority of total operating costs. Discussion with various Navy offices led to the formulation of the following relationships:

- The costs of POL and utilities vary with operating tempo.
- The costs of intermediate maintenance (IMA) and supplies vary with full-time personnel equivalent.
- The costs of repair parts and regular overhaul (restricted availability, technical availability, and selected restricted availability) are fixed for an average ship over a 6-year maintenance cycle.

<sup>4</sup>A special VAMOSC run totaled and averaged the costs per category for all FF1052-class ships for each year from 1977 to 1982 in constant dollars. This run was used to derive "average" cost factors for this class of ships.

### Ship Equipment Operating Tempo

Ships operate in several modes: steaming underway, steaming not underway, and "in cold iron." The programmed operating tempo is normally given by steaming days underway—times when the ship's engines are fired and the ship is steaming in open waters. Steaming days not underway refers to times when the ship's engines are fired, but the ship is in port. When in cold iron, the ship's engines are not operating and the ship depends totally on dock facilities.

While steaming underway, active ships can be assigned to home waters or deployed to foreign waters. The amount of time a ship spends in either category is irregular and based on fleet operations. The programmed operating tempo for an *average* active ship, therefore, may be approximated by the average of programmed steaming days underway in home waters and deployed. Reserve ships do not have overseas missions; they remain in CONUS waters and are programmed as such.

Although operating tempo is programmed in steaming *days* underway, the actual tempo and the related costs are expressed in the data sources in terms of actual steaming *hours* underway. In reality, ships do not steam a full 24 hours for each programmed steaming day. To relate programmed tempo to the cost data available, we derived a relationship between programmed days and actual steaming hours.

Table C.26 shows the programmed and actual steaming days and an estimate, based on dividing steaming hours by steaming days, of the number of steaming hours per steaming day underway. Using the average of deployed and in home waters for active programmed steaming days, we arrived at 19 steaming hours per programmed steaming day underway for both active and reserve FF1052 frigates.

### Ship Equipment Operating Cost Factors

**Fuel.** Fuel is consumed while steaming underway and while steaming not underway. The relationship of programmed days to actual steaming hours has been described; however, a measure for steaming days not underway is needed. From data supplied in Table C.27, a relationship between actual hours underway and hours not underway can be estimated by dividing actual 1983 steaming hours not underway by steaming hours underway. This equals .44 for the USN and .84 for the USNR. Thus, for every *programmed* day of steaming the USN ship will actually steam 19 hours underway and 8.36 (.44 \* 19) hours not underway. A reserve ship will steam underway 19 hours for every programmed day and 15.96 hours not underway.

Table C.26  
OPERATING TEMPO OF NAVY FF1052 FRIGATES UNDERWAY

	Programmed Steaming Days	Actual Steaming Days	Actual Steaming Hours	Actual Steaming Hours/Programmed Steaming Days
<b>USN</b>				
Deployed	202	222	--	20.6 <sup>a</sup>
Home	116	109	--	19.0 <sup>a</sup>
Average	159	165	3022	19.0
<b>USNR</b>				
Home	59	88	1116	18.9

SOURCES: NOP0921 (USN) and NOP09R3 (USNR) for programmed steaming days; [11] for actual steaming days and hours.

<sup>a</sup>Provided by NOP0921 (USN).

Table C.27  
FY 1983 FUEL USE FOR NAVY FF1052 FRIGATES

	Underway		Not Underway	
	Steaming Hours	Barrels /Hour	Steaming Hours	Barrels /Hour
<b>Atlantic Fleet</b>				
USN	2895	16.8	1459	5.5
USNR	1413	14.7	1305	4.9
<b>Pacific Fleet</b>				
USN	3149	17.0	1184	5.8
USNR	819	20.9	582	6.4
<b>Average fleet</b>				
USN	3022	16.9	1321	5.6
USNR	1116	17.8	943	5.6

SOURCE: [11].

While not underway the USN and USNR ships use 5.6 barrels (BBL) per hour. While underway the active and reserve differ. The Navy Energy Office currently uses \$43.26 as the cost for marine diesel fuel. The cost of fuel (excluding oil and lubricants) per year for a ship may be estimated as follows:

$$\text{Fuel Cost} = (A)(B)(C)(D) + (A)(B)(D)(E)(F)$$

where A = Programmed steaming day underway  
B = Historic hours/steaming day  
C = Fuel use/hour underway  
D = Cost/barrel  
E = Historic steaming hours not underway/steaming hours underway  
F = Fuel use/hour not underway

**Utilities.** While in port, Navy ships hook up to utilities external to the ship, that is, electricity, gas, and sewage disposal facilities on the dock. The majority of these costs probably vary directly with the time spent in port not underway. VAMOSC provides the average 1982 ship cost for purchased services as \$278,757 per ship in FY 1983 dollars.<sup>5</sup> This figure includes some costs, such as xeroxing, in addition to utilities. The utility-related costs are the vast majority of this VAMOSC cost datum.

To derive reserve costs and provide a cost estimating relationship, several simplifying assumptions were made. First, we assumed that the cost of utilities varies only by the number of days in port. Possible variability by the number of users on board is ignored. (This is not unrealistic. The active ship always has a full complement, while the reserve ship usually has at least 50 percent of its personnel on board. A light turned on for five people costs the same as a light turned on for one.) Thus, utility costs are assumed to be incurred for any days spent in port. Second, the cost per hour of utilities and purchased services is assumed to be the same for the USN and the USNR.

Given the above, the cost of utilities and purchased services can be expressed as the number of days in port not underway times the cost per day of utilities. The number of days in port equals steaming hours underway plus steaming hours not underway, subtracted from 8760 hours in a year and divided by 24 hours in a day, or 8760 minus total steaming hours/24. This equals 183 in-port days for the USN in both 1982 and 1983 and 279 in-port days for the USNR in 1983.

<sup>5</sup>Average usage for the ship class in FY 1982 equaled \$287,036 in FY 1984 dollars; this was divided by 1.0297 to arrive at FY 1983 dollars.

The USN average cost (\$278,757) for FY 1983 from Ref. C.14 may be divided by the estimated USN port days (183) in 1982 to derive a basic FY 1983 cost per day of \$1523.

**Organizational Supplies.** Supplies include the soap, toiletries, janitorial supplies, paper, and administrative items used by the unit. It is assumed that as the number of full-time people on board the ship increases the use of supplies also increases. VAMOSC provides a figure of \$226,745 for active FF1052 supplies in FY 1983, but gives no cost factors or derivations. Thus, reserve costs must again be derived.

To derive reserve costs, we made the following assumptions. First, the cost per full-time person is assumed to be the same whether the person is on a reserve or active ship. Second, the number of full-time equivalent people on the ship can be estimated by allotting each person the number of days worked in a year and totaling the working days of the entire crew. Reservists are weighted by the number of drill days performed a year. Active personnel and TARs received the full weight of 365 days per year.

Table C.28 shows the necessary calculations to derive full-time manning equivalents (FTMEs). Reservists on USN FF1052 frigates drill only 14 days on the ship; reservists on USNR FF1052 ships drill 24 inactive plus 14 active plus some additional drill days on ship (15 additional drill days are used based on information provided by NOP-064).

The cost of supplies per ship can be expressed as the cost of supplies per FTME multiplied by the number of FTMEs. Cost per FTME is calculated from the VAMOSC USN data as:

$$\$266,745 / 283 = \$943 / \text{FTME}$$

**Repair, Maintenance, and Overhaul.** The Office of the Chief of Naval Operations, Logistics (NOP-04), assumes that ship repair, maintenance, and overhaul activities are usually fixed for a class of ships.<sup>6</sup> On sea-going ships, however, due to the effects of salt water and sea air on parts, all parts are repaired and replaced at regular intervals, regardless of operating tempo. In other words, over a broad range of activity, the maintenance, repair, and overhaul needed is driven by corrosion control needs, rather than by operating tempo. The USN and USNR both currently operate within this range.

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<sup>6</sup>Regular overhaul is scheduled major overhaul with the ship in drydock. Restricted availability overhauls involve specific items on the ship; the ship is unavailable for duty. Technical availability overhauls involve specific items on the ship, but the ship is available for full duty performance. Neither restricted nor technical availability overhauls are prescheduled. Selected restricted availability overhaul is prescheduled restricted or technical availability.

Table C.28  
DERIVATION OF NAVY FULL-TIME MANNING  
EQUIVALENTS (FTMEs)

	Manning (Off + Enl)	% of Year Worked	FTMEs
<b>USN unit</b>			
Full-time active	17+264	100	281
Full-time TARs	0	100	0
Part-time reservists	32	3.8	2
Total FTMEs			283
<b>USNR unit</b>			
Full-time active	6+74	100	80
Full-time TARs	3+85	100	88
Part-time reservists	8+138	14.5	21
Total FTMEs			190

SOURCE: [1].

NOTE: Decimals in the full-time manning equivalent column were rounded to the next higher integer.

**Repair Parts.** For Navy ships, the cost of organizational-level maintenance includes only the costs of repair parts used at the organizational level. Man-hours of labor at the organizational level are costed with the unit's personnel pay. In addition, repair parts are used at the IMA level. VAMOSC provides categories of repair parts without distinguishing between those used at the organizational level and those used at the IMA level. Therefore, we costed repair parts for both levels together. No labor is included. The total cost of repair parts equals the sum of repair parts, exchanges, and organizational issues as detailed in VAMOSC. From VAMOSC, an average FF1052 in FY 1983 had the following costs:<sup>7</sup>

Repair parts .....	\$406,610
Organizational issues .....	85,846
Exchanges .....	169,457
Total .....	\$611,913

<sup>7</sup>VAMOSC direct intermediate maintenance should include some parts. However, the number provided \$94,024 (FY 1983) per ship is suspiciously low compared with other years in the data set. We assume that most of the repair parts costs are included in the categories of repair parts, organizational issues, and exchanges, but recognize that this method may underestimate parts.

**IMA Level Man-Years.** The Ship Maintenance Division of NOP-04 publishes the number of man-hours required for repair and maintenance activities at the IMA level for a given class of ships [C.12]. Taken into account are the man-years available from the organizational level. This includes all types of labor in the IMA pool—whether performed ashore, at tender, by contractors, or by administrators. For FF1052-class ships, the man-years of labor needed, outside the organizational unit, at the IMA level for repair and maintenance are the following:<sup>8</sup>

USN . . . . .	13.4 IMA man-years/year
USNR . . . . .	70.0 IMA man-years/year

The program objectives memorandum (POM) requirement has traditionally used a one-to-six ratio of active-to-reserve man-years for IMA. Recent unpublished research by the Center for Naval Analyses, based on VAMOSC reports and post IMA reports, indicates that the *actual* man-year ratio may be closer to one to three. Using the CNA ratio and 13.4 man-years/year for the USN would substantially reduce the USNR estimate to 40.2 man-years/year. Because the CNA evidence remains tentative and unpublished, we have used the POM requirements in this analysis. However, this issue is still under study.

Both the Atlantic and Pacific fleets assume that IMA-level maintenance is productive only 45 percent of the time. To obtain the actual man-years required at the IMA level, one must therefore divide by .45; this yields the following productive man-years needed at the IMA level for FF1052 class ships:

USN . . . . .	29.8 man-years/year
USNR . . . . .	155.5 man-years/year

The cost of an average IMA man-year in the Navy is \$15,374 for FY 1983.<sup>9</sup> Using a simplifying assumption that all labor costs are incurred by naval personnel and that no contractors are used, the cost of labor equals productive man-years multiplied by cost/man-years.

**Overhaul.** During the 6-year maintenance cycle, an active ship will have one major overhaul, while a reserve ship will have phased SRA overhaul. In fact, the USN is moving toward the USNR's phased

<sup>8</sup>See Refs. C.12 and C.13. The USNR figure is a weighted average of the Atlantic and Pacific fleets.

<sup>9</sup>This is the pay of an E-6 derived from the USN Budget Justifications. It includes no special or incentive pays. VAMOSC reports that the average IMA personnel is an E-6.

overhaul methods. We converted VAMOSC data for the period FY 1977 to FY 1982 for all 46 USN ships to current dollars and averaged the costs over 6 years to cover the full maintenance cycle. The result is \$4,766,087 per ship.

Regular overhaul .....	\$3,440,880
Selected restricted availability .....	581,366
Restricted availability .....	309,574
Technical availability .....	292,265
Other depot .....	142,002
Total .....	\$4,766,087

**Unit Training Munitions.** Training munitions for the unit are assumed to be fixed for all ships in each class, since both the USN and USNR receive the same amount of munitions training. The FY 1982 average active cost converted to FY 1983 dollars from VAMOSC is \$413,283 per ship. This is used for both USN and USNR.

#### Aircraft Equipment-Related Costs

The various elements of cost associated with the annual operations of a squadron's aircraft are petroleum, oil, and lubricants; maintenance material; replenishment spares; training ordnance; modifications; depot maintenance; and intermediate level maintenance.

No single source in the Navy provides all of the above costs. Lacking a consolidated source for aircraft operating costs, we developed the various factors from information obtained from various Navy organizations and documents. The resulting factors and their sources are described below.

#### Aircraft Equipment Operating Tempo

The various sources reporting the programmed flying hours of USN and USNR squadrons describe different programs. The programmed flying hours vary among the sources because some new documents reflect budget changes that earlier documents do not, or some documents aggregate the programmed hours of both the Navy and Marine Corps into a single factor. Because of the differences in the documented flying programs, the most recent budgeted flying hours were requested from the Assistant for Flying Hour Programs (NOP-51C) under the Deputy Chief of Naval Operations, Air Warfare. This office coordinates the flying hours programmed for the various segments of Naval Aviation. The current factors, reflected in the President's FY

1984 budget (NOP-20) are:

USN F-4S TACAIR . . . . .	273 hours/aircraft/year
USNR F-4S . . . . .	248 hours/aircraft/year

The programmed flying hours for the USNR squadrons include the peacetime flight training of the selected reserve aircrew members who augment active squadrons. The flying hours for the selected reserve augment aircrews, totaling approximately 29 hours per aircraft per year, are subtracted from the USNR aircraft operating hours and added to the USN flying programs in order to estimate the costs appropriate to each component. The resulting aircraft flying hours per year are 302 for the USN squadron and 219 for the USNR squadron.

#### Aircraft Equipment Operating Cost Factors

**POL and Maintenance Material Costs.** Petroleum, oil, and lubricants represent the gas and oil consumed during flight operations. Maintenance material are the bits and pieces used by organizational and intermediate maintenance during the repair and maintenance of aircraft components and systems. The Flying Hour Cost Reporting System, monitored by NOP-51, captures these elements of operating costs. The cost per flying hour in FY 1983 for these two elements was \$2403 for USN and \$1913 for USNR F-4S aircraft.

The fixed costs part of maintenance material is relatively small compared with the variable maintenance material costs. Because no fixed factors are available, we treat maintenance material as a completely variable cost.

We obtained factors from NOP-51 for the total of these two cost elements. The POL costs per flying hour from the Flying Hour Projection System of the Navy Aviation Logistics Center (NALC) budget were compared to the total NOP-51 cost factors to estimate the maintenance material cost per flying hour. The FY 1984 NALC budget uses a factor of \$1593 for active and \$1326 for reserve POL cost per flying hour. Because of the difference between FY 1983 and FY 1984 dollars, the NALC POL factors were first valued to FY 1983 dollars, using a factor of 1.0256. The difference between the NOP-51 cost factor and the NALC POL factor provided the following estimate of maintenance material cost per flying hour in FY 1983 dollars:

	USN	USNR
POL/FH . . . . .	\$1634	\$1360
Maintenance material/FH . . . . .	769	553

**Replenishment Spares.** Replenishment spares costs are for the replacement components and subsystems required for aircraft maintenance and support. These costs are funded in the appropriations budget rather than in the operating budget. According to information in the FY 1982 VAMOSC report, replenishment spares cost \$49 per flying hour in FY 1982 dollars or approximately \$50 per flying hour in FY 1983 dollars.

**Training Ordnance.** This element includes the cost of bombs, missiles, and other munitions expended during annual squadron training exercises. The missile allowances (based on information from the Office of Naval Warfare, Tactical Readiness Division, NOP-953) in combination with the unit cost of the missiles (from the Program Planning Office, General Planning and Programming Division, NOP-901F) result in an annual training ordnance cost of \$1,246,035 for USN squadrons and \$498,414 for USNR squadrons.

**Modifications.** This category includes the procurement cost of modification kits plus the associated logistic support investment costs and nonrecurring engineering costs. According to the FY 1982 VAMOSC reports, modification costs are approximately \$180,250 per aircraft in FY 1982 dollars or \$185,250 per aircraft in FY 1983 dollars.

**Depot Maintenance.** Depot maintenance costs include expenses for the repair and rework of aircraft subsystems at Naval Aviation rework facilities (NARFs) or by commercial organizations. Depot actions include the scheduled rework of airframes, termed scheduled depot-level maintenance (SDLM), and the major repair of jet engines and avionics components. The SDLMs are scheduled on a calendar interval basis, independent of usage, and represent a fixed cost per aircraft. The engine and component repair actions are a function of the aircraft usage and therefore a variable cost per flying hour. The fixed and variable factors are assumed to be the same for USN and USNR aircraft.

The Plans, Policy and Fleet Support Branch of the Deputy Chief of Naval Operations, Air Warfare (NOP-514) provided the following information:

SDLM interval . . . . .	48 months
SDLM duration . . . . .	4 months
SDLM cost . . . . .	\$586,300
Engine rework . . . . .	\$129/flying hour
Component rework . . . . .	\$533/flying hour

Amortizing the SDLM expenses to an annual basis results in a cost of approximately \$135,300 per aircraft per year (12 months/[4 + 48])

months) \* (\$586,300). Therefore, the depot maintenance cost factors are \$135,300 per aircraft and \$662 per flying hour.

**Intermediate Maintenance.** Intermediate maintenance costs include the parts and labor for repairs performed by the Naval Air Stations and carrier Aircraft Intermediate Maintenance divisions (AIMDs). The repair parts cost is already included in the maintenance material and replenishment spares cost elements. The labor costs include two separate types of AIMD personnel. Most repairs theoretically are made by squadron personnel assigned on a temporary basis to the AIMDs. The cost of these personnel are included in the squadron personnel costs. The second type of AIMD personnel is the permanent party of the AIMD. These people theoretically supply the administrative overhead and the facility and test equipment support at the AIMD.

Since these personnel are part of the fixed cost of intermediate maintenance and the cost analysis is considering only the variable elements of cost, the cost of the AIMD permanent party is not included in the squadron cost comparisons. Therefore, there is no separate cost factor for intermediate-level maintenance.

### **CASE STUDY COST CALCULATION METHODS AND RESULTS**

The case study results were calculated using the cost factors and manning levels discussed above and the cost calculation formulas immediately following. Tables C.29 and C.30 display the case study results.

### **NAVY CASE STUDY COST CALCULATION FORMULAS**

#### **PERSONNEL COSTS**

##### **Military Pay**

1. (Rated Officers) \* (Rated Officer Pay)
2. (Rated Enlisted) \* (Rated Enlisted Pay)
3. (Nonrated Officers) \* (Nonrated Officer Pay)
4. (Nonrated Enlisted) \* (Nonrated Enlisted Pay)
5. (TAR Officer) \* (TAR Officer Pay)
6. (TAR Enlisted) \* (TAR Enlisted Pay)

##### **Civilian Pay: (Civilians) \* (Civilian Pay)**

##### **Training and Acquisition Costs**

1. Aviation Unit
  - a. Pilot Training: (Pilots) \* (Rated Officer Turnover) \* (Pilot Training Costs)

- b. Other Rated Officer: (Rated Officer - Pilots) \* (Rated Officer Turnover) \* (Other Officer Aircrew Training Costs)
- c. Nonrated Officer: (Nonrated Officer) \* (Nonrated Officer Turnover) \* (Nonrated Officer Training Costs)
- d. Enlisted: (Enlisted) \* (Enlisted Turnover) \* (Enlisted Training Costs)
- 2. Ship Unit
  - a. (Officers) \* (Officer Turnover) \* (Ship Officer Training Cost)
  - b. (Enlisted) \* (Enlisted Turnover) \* (Ship Enlisted Training Cost)

Other Reserve Training (for reserve part-time personnel only)

- 1. (Rated Officers + Nonrated Officers) \* (Other Officer Training Costs)
- 2. (Rated Enlisted + Nonrated Enlisted) \* (Other Enlisted Training Costs)

Other Personnel Costs

- 1. (Rated + Nonrated Officers - TAR Officers) \* (Other Personnel Costs/Officer)
- 2. (Rated + Non-Aircrew Enlisted - TAR Enlisted) \* (Other Personnel Costs/Enlisted)
- 3. (TAR Officer) \* (Other Personnel/TAR Officer)
- 4. (TAR Enlisted) \* (Other Personnel/TAR Enlisted)
- 5. (Civilians) \* (Other Personnel Costs/Civilian)

**SHIP EQUIPMENT OPERATION COSTS**

POL: Fuel Costs = (A) \* (B) \* (C) \* (D) + (A) \* (B) \* (E) \* (F) \* (D)

where A = Programmed Steaming Day Underway

B = Historic Hours/Steaming Day

C = Fuel Use/Hour Underway

D = \$ Cost/Barrel

E = Historic Steaming Hours Not Underway/Steaming Hours Underway

F = Fuel Use/Hour Not Underway

Utilities: (Utility Cost/Day) \* (Days Not Underway)

Supplies: (Supply Cost/FTME) \* (FTME)

Repair Parts: (Repair Parts Cost/Ship)

IMA Maintenance Labor: (Productive IMA Man-years) \* (Cost/Man-year)

Overhaul: (Overhaul Costs/Ship)

Training Munitions: (Training Munition Costs/Ship)

**AIRCRAFT EQUIPMENT OPERATION COSTS**

POL: (PAA) \* (FH/PAA) \* (POL COSTS/FH)

Aircraft Maintenance Material: (PAA) \* (FH/PAA) \* (Maintenance Material Costs/FH)

Training Ordnance: Training Ordnance Costs/Squadron  
Depot Maintenance

1. (PAA) \* (FH/PAA) \* (Depot Maintenance/FH)
2. (PAA) \* (Depot Maintenance/PAA)

Replenishment Spares: (PAA) \* (FH/PAA) \* (Replenishment Spares/FH)

Modification Kits: (PAA) \* (Modification Costs/PAA)

Table C.29

NAVY UNIT OPERATING AND SUPPORT COSTS,  
FF1052 FRIGATE  
(\$ FY 1983 million)

	USN	USNR
Personnel and support		
Pay and allowances		
Officer--part-time	0	0.06
Officer--full-time	0.64	0.36
Enlisted--part-time	0.10	0.45
Enlisted--full-time	4.59	2.81
Total	5.34	3.69
Other personnel and support		
Officer	0.12	0.07
Enlisted	1.55	0.89
Total	1.67	0.96
Replacement training		
Pilot	0	0
Other rated officer	0	0
Nonrated officer	0.11	0.08
Enlisted	0.96	0.38
Other reserve training	0	0.01
Total	1.07	0.47
Total personnel and support	8.08	5.12
Equipment		
POL	2.53	1.09
Utilities	0.28	0.42
Supplies	0.27	0.18
Repair	0.66	0.66
Intermediate maintenance	0.46	2.39
Overhaul	4.77	4.77
Ordnance	0.41	0.41
Total equipment	9.38	9.93
Total unit costs	17.46	15.05

NOTE: Sums may not add because of rounding.

**Table C.30**  
**NAVY UNIT OPERATING AND SUPPORT COSTS,**  
**F-4S, 12 PAA**  
**(\$ FY 1983 million)**

	USN	USNR
<b>Personnel and support</b>		
<b>Pay and allowances</b>		
Officer--part-time	0.08	0.41
Officer--full-time	1.27	0.22
Enlisted--part-time	0	0.37
Enlisted--full-time	4.09	1.77
Total	5.44	2.78
<b>Other personnel and support</b>		
Officer	0.23	0.09
Enlisted	1.33	0.52
Total	1.56	0.60
<b>Replacement training</b>		
Pilot	2.53	0
Other rated officer	0.85	0
Nonrated officer	0.02	0.01
Enlisted	0.82	0.13
Other reserve training	0.00	0.02
Total	4.23	0.16
<b>Total personnel and support</b>	11.23	3.54
<b>Equipment</b>		
<b>POL</b>	5.92	3.57
<b>Maintenance supplies</b>	2.79	1.45
<b>Replenishment spares</b>	0.18	0.13
<b>Depot maintenance</b>	4.02	3.36
<b>Modifications</b>	2.22	2.22
<b>Ordnance</b>	1.25	0.50
<b>Total equipment</b>	16.38	11.24
<b>Total unit costs</b>	27.61	14.78

NOTE: Sums may not add because of rounding.

## NAVY GLOSSARY

ACDUTRA	active duty training
ADP	automated data processing
AIMD	Aircraft Intermediate Maintenance Department
BBL	barrel
BOS	base operating support
CNA	Center for Naval Analyses
CONUS	continental United States
FTME	full-time manning equivalent
IDT	inactive duty training
IMA	intermediate maintenance activity
NALC	Navy Aviation Logistics Center
NARF	Naval Aviation Rework Facility
NAS	naval air station
NFO	naval flight officer
NPS	nonprior service
O&M	operations and maintenance
O&S	operations and support
PCS	permanent change of station
PFM	Program Factors Manual
POL	petroleum, oil, and lubricants
POM	program objective memorandum
RA	restricted availability
RAD	resource allocation document
ROH	regular overhaul
ROTC	Reserve Officer Training Corps
RPM	real property maintenance
SDLM	scheduled depot level maintenance
SRA	selected restricted availability
TA	technical availability
TAD	temporary assigned duty
TAR	training and administration of reserves
UPT	undergraduate pilot training
USN	United States Navy
USNR	United States Naval Reserve
VAMOSC	Visibility and Management of Operating and Support Costs

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*This report*

Presents a consistent and complete methodology for comparing annual operating and support costs of active and reserve units within and across all components of the force. Existing service models and data were modified or manipulated to create active and reserve annual cost models and cost factors. The report describes the general approach and uses service specific case studies to demonstrate methods and cost factor derivations. Case studies include: Air Force F-4D and C-130E squadrons; Army mechanized infantry, tank, field artillery, and combat engineering battalions; and Navy F-4S squadrons and FF1052 frigates. Results, given in FY 1983 dollars, show wide variances in difference in annual active and reserve unit costs across units and services emphasizing the need for a case by case approach to unit costing. Technical appendices present the detailed descriptions of cost factor derivations and data sources. A companion document, R-3210/1-RA, provides a summary of this report in executive briefing format.

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